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An Illustrated Weekly Journal

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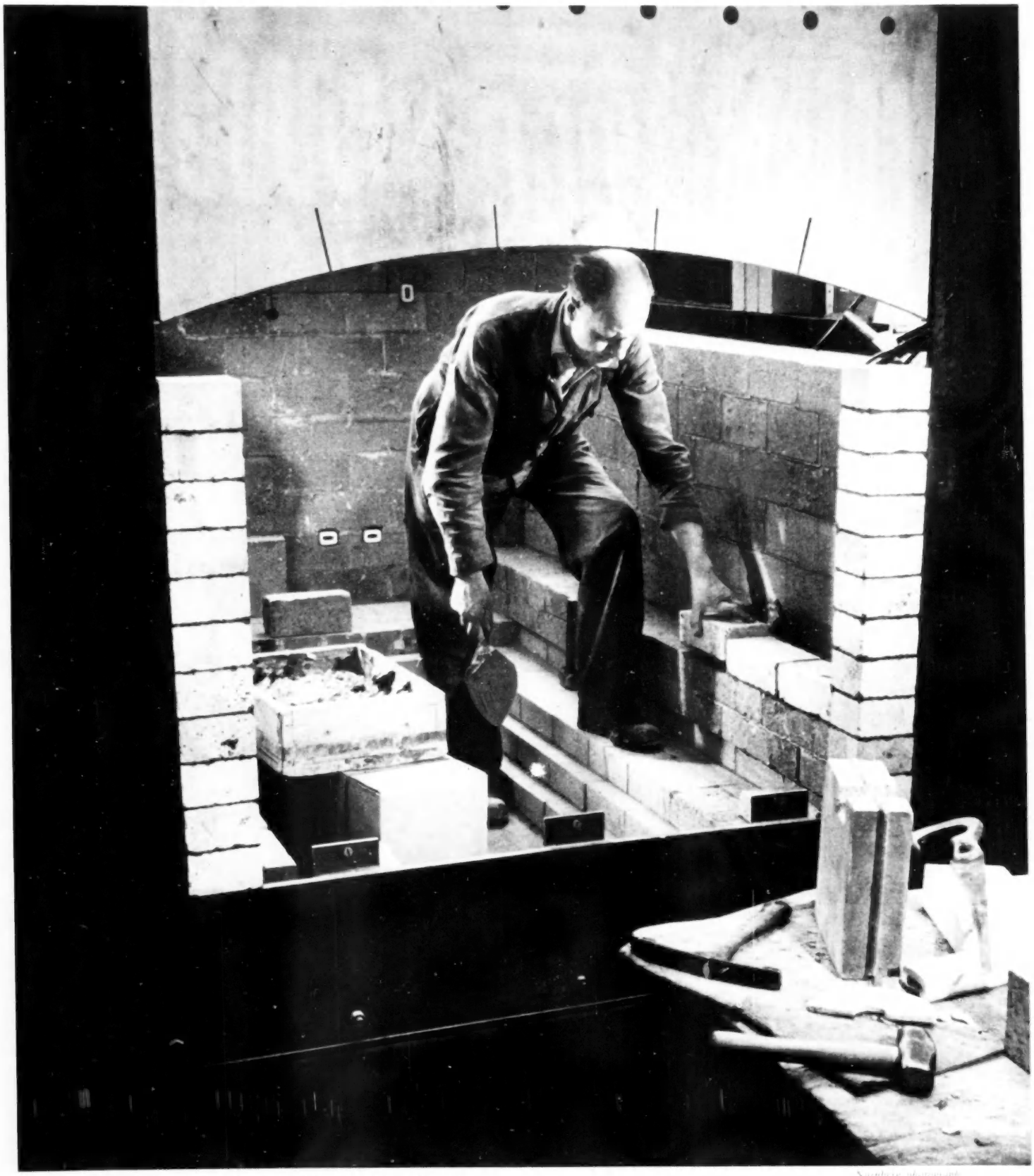

BRICKWORK FOR AN ELECTRIC BATCH FURNACE

Numbers photographs from ENGINEERING

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THE DESIRE FOR RECOGNITION

MEMBERS of the three major engineering institutions—Civil, Mechanical and Electrical—are a minority among the people in executive positions in the engineering industries. For every one member there are at least three or four men who possess either different qualifications (usually lower) or no qualification at all. This situation is a serious obstacle to those members who wish to hasten the day when the public and Press alike regard engineers as belonging to a profession as recognisably distinct and worthy as that of the law, medicine, accountancy and the like.

There is yet another obstacle. Since the Charters of the three institutions forbid activities of the kind that would advance the personal and professional interests of the members, the only body endowed with the necessary power is the Engineers Guild—but the Guild's membership is only a minority of the institutions' members. Thus the Guild is not in a strong position. It speaks directly for only a fraction of all chartered engineers, who are themselves only a small part of the people with responsibility and power in the industries. Out of this weakness, however, strength may grow. Whereas a larger and more representative association might be slow to act because of its own viscosity, the smaller body is more fluid and consequently can operate more decisively. This month the Guild has embarked on "a realistically ambitious, new and progressive policy designed to meet the needs of professional engineers to-day." The policy is six-pronged: to establish a definition of the engineering profession; to carry out a survey of salaries and other conditions of service in the profession; to encourage the engineer to equip himself to accept management and administrative functions; to carry out a public relations programme on behalf of professional engineers; to increase the resources of the Guild by raising subscriptions above the level fixed in 1951; and to increase the resources and strength of the Guild by recruiting more members.

The most promising of these projects is the survey of salaries and conditions of service. When it is completed and published it will focus public attention on the only aspect of employment that is of universal interest—the rewards which engineers are getting for their services. No doubt it will surprise many people to learn that some of the famous whom they thought were capitalists, or bureaucrats, or scientists, or technicians, or technologists, are in fact engineers. In this respect the survey could have a certain recruiting value for the profession. Much good, also, will come from any general discussion which may be stimulated about the relative values of the engineering profession and other professions. And engineers themselves will be eager to examine the survey from a purely personal point of view, to see how their individual salaries fit into current salary scales. All of which could be useful publicity for the Guild.

The public relations programme has been designed (1) "to increase public awareness of the work and responsibilities of the professional engineer and of his fundamental importance in the economy of the country; and (2) to encourage proper acknowledgment of the part played by the professional engineers concerned, wherever references are made to engineering undertakings." The Guild has already advanced some way in this direction, particularly by facilitating reports of Guild meetings in the national and provincial Press. A major handicap is, of course, the lack of a simple definition of the professional engineer, though a comprehensive definition published several years ago has Government support and has been accepted by most of the principal engineering institutions of the British Commonwealth, the United States and Western Europe. The three senior engineers who have been appointed by the Guild to submit a draft definition are faced with a difficult and delicate task. They will be asked to pay regard to the charters of the three major institutions (that is relatively simple), and to the Government report on scientific and engineering manpower in Great Britain which was published last year. This report introduced a complication. It defined qualified scientists and engineers as corporate and graduate members of 15 professional institutions, or associates of eight educational institutions, as well as university graduates of the appropriate types. Such a definition is much broader than membership of the three major institutions, which is the present restriction on membership of the Guild.

State registration of engineers, which has often been proposed in the past, would be of doubtful value to the Guild or the institutions; it would not be welcomed by all professional engineers—however defined. A closed shop might reduce the quality and usefulness of a profession in which the creative element is dominant. There may also be some significance in the fact that well over a third of all engineers in this country (using the Government report definition) are employed by the State—in the nationalised industries, public authorities, local authorities, and education.

In recent years the major engineering institutions have worked harmoniously together and an attitude of live and let live

has been adopted to the younger institutions. The Civils and the Mechanicals, for example, can look back dispassionately at the little-known circumstances surrounding them and George Stephenson over a hundred years ago (as a special article in this issue shows). Whatever is done in the future must therefore not throw away these solid gains. Unity of the profession is essential. Inevitably it will call for a conscious readiness to make concessions.

* * *

Plain Words

The Minister of Transport's announcement that the Government is going to find another £240 million for roads is good news. A three-point programme is envisaged. First, a start is to be made on a major network of trunk roads—motorways restricted to fast, heavy traffic. Secondly, efforts are to be made to clear away urban bottlenecks. And thirdly, there is to be put in hand a reasonable number of smaller works, costing £100,000 each, to make a contribution to specific traffic problems in various parts of the country. The announcement is welcome. Though the volume of road work has been increasing steadily over the past few years, it was patently not in keeping with our needs, nor was it on a par with road construction on the Continent or in North America. One had almost come to believe that in higher government circles it had been decided that we had missed the "motorway age" anyway, and that it was better to save the money and the effort in order to give the railways their long overdue square deal.

At last, too, the real difficulty of road making in this country has been recognised. It is not the financial one of meeting the cost, nor is it a lack of engineering ability which would enable good roads to be built quickly and economically. It is the inertia of public opinion which admits, or even supports, a landlord or occupant clinging to property which interferes with road improvements, irrespective of the offer of reasonable compensation or of the benefit that could accrue to the community.

Now that the programme has been sanctioned, the next task is to plan each individual contract so that it can be completed with the minimum interference to traffic. This means upsetting transport for the shortest possible time. It would be better to seal off a section of road and divert the traffic round a longer route for a week or even a month than to have a caravan of heavy lorries, business-men's cars and holiday makers' coaches picking their way alternately through concrete mixers, shovels and buckets for several years. As Lancashire has recently demonstrated, a 26 ft. concrete carriageway can be laid at the rate of 500 ft. a day. A medium-sized excavator can get out 800 cub. yds. of spoil in one shift. There is no need for a £100,000 contract to take 18 months to complete. A concentration of resources on each job in turn would be better than spreading them simultaneously over many jobs.

PROBING SPACE

With the opening of the International Geophysical Year and the almost imminent launching of the first artificial satellites—mankind stands on the threshold of the space-flight era. To survey the possibilities that lie before us in this field, the Symposium on High Altitude and Satellite Rockets was held last week at the College of Aeronautics, Cranfield, under the joint organisation of the Royal Aeronautical Society, the British Interplanetary Society, and the College of Aeronautics. At the end of this article will be found a list of the papers that were discussed; they are to be published in a single volume later this year. We give below a summarised general picture as reflected from the written papers.

From the research scientist's viewpoint, the high-altitude research rocket can reveal information that cannot be obtained from ground-based studies—data on the intensity distribution in the solar spectrum, which affects the earth's atmosphere, on the ionosphere, and on dynamo currents and magnetic variations and storms. The rocket also makes possible the direct measurement of the pressure, density, temperature and composition of the upper atmosphere, and enables experiments to be carried out to assist in these measurements. The short duration of rocket flight, however, limits the type of work that can be carried out, and hence the need for the satellite observing stations which are to be launched in the American and the Russian I.G.Y. projects. Among the measurements that will be made from the American Vanguard satellites are extent of the cloud cover over the earth, the total intensity of primary cosmic radiation, and magnetic observations.

LAUNCHING VANGUARD

A satellite launching vehicle must first raise the satellite payload several hundred miles above the earth, where the air density is extremely low, and must then project the satellite at high velocity on a nearly circular path concentric with the earth's surface. In practice, the orbit will be an ellipse.

The Vanguard satellite is a 20 in. sphere weighing 21·5 lb.; its launching vehicle weighs 22,600 lb. and comprises a three-stage rocket of which the first two stages are guided by internal controls. The third stage is constrained to a straight flight path by spinning it about its longitudinal axis prior to firing. The airframe, without fins, comprises two cylindrical sections, the forward one of 32 in. diameter; the after section has a diameter of 45 in. The two cylinders are joined by a conical section and the forward cylinder is terminated by a conical nose. The composite vehicle is 71 ft. long.

The first stage is a guided liquid-propellent booster rocket that provides most of the energy to raise the remaining two stages to orbital height and, by virtue of its inclined flight path, about 15 per cent. of the required orbital velocity. The major propellents, oxygen and gasoline, are fed to the rocket motor by turbine-driven pumps. The thrust at take-off is approximately 28,000 lb. The motor is gimbal mounted so that it can be tilted by electro-hydraulic controls to control the vehicle's orientation and flight path. A third propellent, hydrogen peroxide, is decomposed to drive the turbine. Helium gas is used to pressurise propellent tanks and to operate pneumatic controls. Guidance information is obtained from an inertial reference system carried in the second stage which separates and fires at the end of first stage burning.

The second stage, the "brain" of the vehicle, is a liquid-propellent rocket that attaches to the forward end of the first stage and also carries in its nose the third stage and the satellite payload. The propellents, nitric acid and dimethyl-hydrazine are fed directly to the motor from high-pressure tanks integral with the airframe's skin. The motor develops a thrust of 7,500 lb. at operating altitude. Again, the pressurising gas is helium. The motor is gimbal-mounted and positioned in pitch and yaw, as in the first stage. An array of small rocket motors, using the remaining helium as propellent, provides complete control of orientation during second-stage coasting flight. The reference system, located wholly within the second stage, consists of three gyroscopes and a pitch programmer that controls the flight path inclination. This reference system provides the necessary guidance during three periods of flight: first-stage powered flight, second-stage powered flight, and second-stage coasting flight. It is desired to fire the third stage at the zenith of second-stage coasting flight. For this purpose, the second stage carries a coasting-time computer that determines the velocity at second-stage burn-out and predicts when zenith will be reached.

The nose cone which protects the satellite is jettisoned early during second-stage burning, after which time exposure of the satellite would not be detrimental.

The third stage is a solid-propellent rocket that delivers 2,300 lb. thrust at operating altitude. Here, low structural weight and simplicity are mandatory. The third stage is spun while it is in the second stage, and then it separates and ignites. This last stage is fired at orbital height and it provides about 50 per cent. of the required orbital velocity.

The satellite is attached to the forward end of the third stage and is to be separated after orbital velocity is attained, by means of a spring mechanism actuated by a mechanical timer. The flight path of the vehicle is shown in Fig. 1.

Although the programme for test and verification of components and systems on the

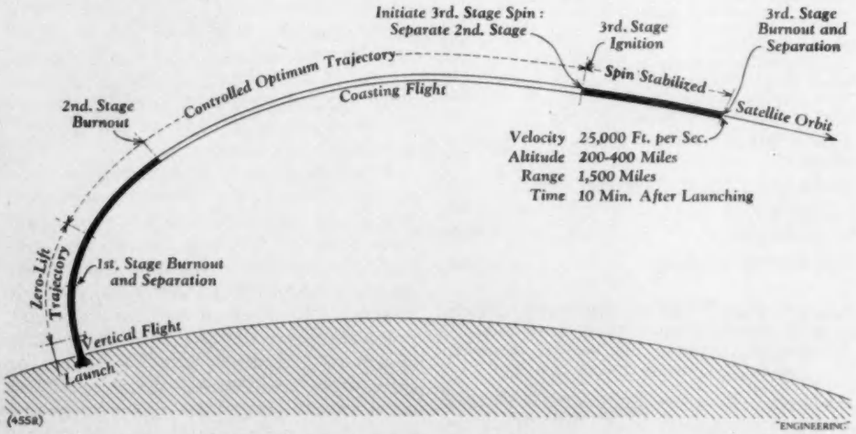

Fig. 1 The trajectory of the Vanguard satellite, which is projected into its orbit by a three-stage rocket.

ground is extensive, the development could not be completed without a preliminary flight test programme. The early test vehicles contain only parts of the final vehicle so that some systems (such as engines, controls or structures) may be evaluated separately. The later test vehicles are complete three-stage rockets of the final configuration, but they carry a heavy payload of performance measuring instruments—much more than the instrumentation permissible in the final satellite vehicle.

The actual satellite launching, six of which are scheduled, will begin upon completion of the test vehicle firings.

SKYLARK

Britain's contribution to upper atmosphere research during the I.G.Y., rather less ambitious than the satellite projects, will be carried out by the Skylark upper atmosphere sounding rocket. Skylark is powered by a solid propellant motor (Raven) giving a nominal thrust of 11,500 lb. for about 30 seconds. It is designed to carry a payload of 100 to 150 lb. to 500,000 ft. with a take-off weight of roughly 2,500 lb.

Stabilising fins are secured to the rear end and the instrumentation section is fixed to the forward end; this consists of a cylindrical parallel section and a conical nose giving a total of some 5 cub. ft. of useful payload space. The nose cone, where aerodynamic heating will be fairly severe, is made of stainless steel and in some experiments a part of it will be jettisoned at high altitude by a spring mechanism. The parallel bay and the nose cone can be pressurised independently.

Skylark is launched from an 80 ft. tower, largely built from standardised Royal Engineers' Bailey bridge sections, as shown in Fig. 3. This tower was designed by the Royal Aircraft Establishment and fabricated by the Royal Ordnance Factory at Woolwich, and has been erected at Woomera. The launcher is trainable on gimbal mounts to allow a deviation from the vertical of plus 15 deg. to minus 5 deg. in elevation and plus or minus 10 deg. in azimuth.

Each rocket carries as standard a 465 Mc/s. telemetry sender, Doppler transponder (104 to 208 Mc/s.) and a 6 cm. microwave beacon. Circular polarisation is used to minimise gaps in reception. The 465 Mc/s. telemetry uses time multiplexing with 23 low-frequency channels; for high-frequency recording, provision is made for a second sender which omits time switching.

The power supplies, so often ignored by those who plan elaborate and exciting experiments, take up much space and payload. For example, with air-glow experiments, the photomultipliers require a 1,050 volt supply, the d.c. amplifier 100 volts and a very stable 6·3 volt heater supply, and the output has to be biased by very stable bias batteries. These batteries, when potted in resin as a normal precaution to prolong life and reliability, weigh 17½ lb., and occupy one complete bulkhead, 6 in. deep.

To increase the altitude performance, a lighter fin, directly attached to the motor case is planned, together with a small separating boost motor, burning for 2 to 3 seconds; this should raise the maximum height to approximately 700,000 ft. A parachute recovery system for the nose section is being developed.

Outstanding advances in instrument design are an essential outcome of the upper-atmosphere research programme, since the accelerations and vibrations which the rocket recording and telemetering equipment has to withstand are quite outside the experience of normal commercial practice—and, moreover, such equipment must be light in weight and compact. For pressure measurements in the Skylark, the Royal Aircraft Establishment have developed a Pirani gauge with a pressure range from 10^{-2} mm. to 30 mm. Hg.—and, experimenatlly, the range has been extended to 800 mm. Hg. by oscillating or rotating the tungsten filament; and a radioactive ionisation gauge is under development with a range from 10^{-4} mm. to 850 mm. Hg.

The Skylark vehicle is unguided and uncontrolled, and it is therefore necessary, for certain experiments, to measure its attitude. There are three possible ways under consideration—(1) determination of the direction of the sun's radiation vector and of the earth's magnetic field vector with respect to the missile, by means of photocells and a fluxgate magnetometer mounted in the missile, (2) by photography of known ground features by two or more cameras in the missile and (3) by microwave interferometers in the missile working in conjunction with ground transmitters.

For programming and sequencing the experiments on Skylark, a universal timer, operated by a previously-prepared punched tape, is under development.

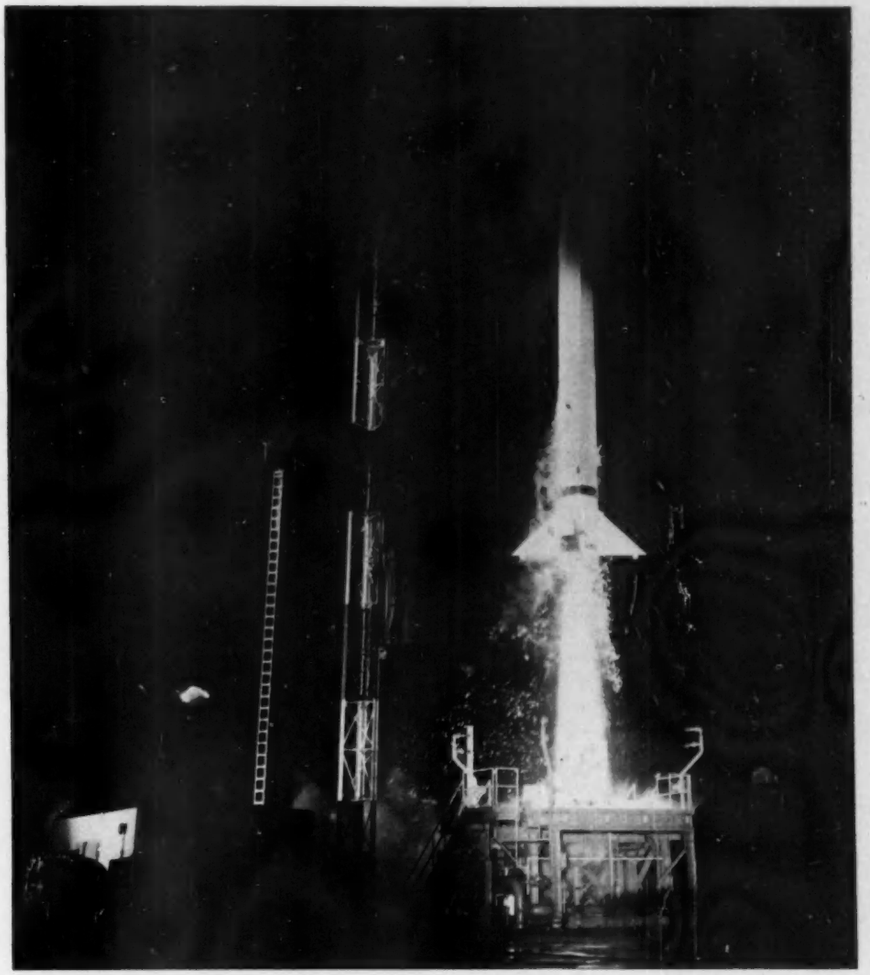

Fig. 2 The launching of the first Vanguard test vehicle—part of a test programme to prove the components and systems before launching the six satellites themselves.

SATELLITES UP TO 100 TONS

In the Vanguard satellites, a payload of some 10 kg. of scientific instruments will be projected into a fairly close near-circular orbit about the earth by means of a three-stage rocket with an initial mass of about 10 tons. Designers of missiles foresee no inherently unassailable obstacles to achieving very much higher payloads, and in constructing satellites capable of complete escape from the earth, orbiting in parabolic or hyperbolic paths, using larger rockets with all-up weights up to, say, 100 tons—in fact, on the basis of geometrical similarity, it seems that the structural efficiency of the missile will not reach an optimum until launching weights reach values of the order of 50 tons. In designing large missiles, the main difficulties are likely to be those brought about by the design refinements that are essential to keep down size and cost. The efficient vehicle must be designed for the optimum flight path, which itself depends upon the resistance of the missile to heat—that is, on its size and structural design, which in turn are influenced by the thrust-to-weight ratio, the number of rocket stages, and so on—so that "the best combination can only be found by a process of feed back and reiteration."

As to the type of rocket engines to be used—it seems that, for the large satellite, the size of solid-fuel rockets will be prohibitive and, up to 100 tons, conventional liquid-chemical propellents—possibly of a more powerful type such as hydrazine/fluorine, for the second and third stages of multi-stage vehicles—are likely to be used. For very large rockets, the present trend of thinking is towards clusters of smaller engines rather than a single large engine per stage; and whether the engines should be fired in stages, or in parallel, can only be considered in relation to the individual design.

COMING BACK TO EARTH

For launching manned vehicles into an orbit, very much greater payloads, of the order of 5 to 10 tons, must be carried, because man will only function over a limited temperature range and with an air supply, and he will require ultimately to return safely to earth. Even so, manned satellite vehicles may be a practical proposition with suitably-developed conventional chemical fuels. The energy of the vehicle must be absorbed almost entirely by the resistance of the air, which will result in enormous surface heating effects and would, most probably, call for refrigeration to keep the structure from disintegrating, apart from any question of crew comfort.

One suggestion that has been made for giving

Fig. 3 The Skylark launching tower, erected at Woomera, is trainable on gimbal mounts.

the crew " at least a slender chance of survival " is that the vehicle should be designed to produce maximum drag, associated with maximum negative lift—that is, the lift force would direct the vehicle towards the earth's centre during its initial deceleration through the atmosphere. At all speeds above 5 miles per second, the vehicle would fly upside down by ordinary aircraft standards; at this speed it would execute a slow roll so as to reverse the direction of lift.

Suitable shapes for such a high-induced-drag high-lift vehicle would suggest a low-aspect-ratio wing of square, circular or delta planform. If the vehicle is to be spin-stabilised, thus avoiding the necessity for a tail surface, the circular planform has an advantage—and it is also a good shape for the pressure cabin. A section through such a vehicle might look like that shown in Fig. 4; at an angle of incidence of minus 45 deg., the forward-facing flat-plate surface will be the hot surface, and there will be a perfect vacuum on the other surface provided that the flow has to turn through more than 8·3 deg., as shown. The annulus surrounding the pressure bubble, which houses the crew and equipment, assists in keeping heat off the canopy. The hot surface, which forms the main structural member of the vehicle, will be expected to burn off appreciably during re-entry. The heat input will, in fact, be formidable unless the wing loading is kept very low indeed—and the pilot will have to master a very tricky approach technique —nipping in and out of the earth's atmosphere alternately to brake the vehicle and to cool it down.

MEN ON THE MOON

To get a human crew to the surface of the moon and back, however, a multi-stage rocket of, perhaps, 100,000 tons all-up weight would probably be required with rockets based on existing propellents. At a cost of £5,000 to £10,000 per ton, this is clearly not a practicable proposition.

For reasonable economy, it seems that the minimum exhaust velocity for a man-carrying moon-rocket will have to be in the region of 6,000 metres per second. There are two potential methods of rocket propulsion that may make such velocities possible: the use of metastable or unstable propellents, such as the recombination of single hydrogen atoms, and the use of nuclear power. The latter seems the more likely proposition, since it is very doubtful whether monatomic hydrogen can be prepared and stored on a commercial scale; it would be fabulously expensive and would require formidable safety precautions in storage.

Nuclear-powered rockets—also a formidable development problem—would most probably use the nuclear reaction to heat a working fluid which would then be expanded through a conventional nozzle. Hydrogen is a likely working fluid because of its high specific heat and energy.

Although it seems unlikely that electrical or ionic methods of propulsion will provide sufficient thrust for ascending from the earth's surface, such engines could accelerate a vehicle from an orbit around the earth and build up a velocity high enough to penetrate to the outer planets. An electrical propulsion system might involve an arc discharge to heat a working fluid—probably sodium—and expand it through a nozzle. Alternatively, electrical acceleration of the working fluid might be carried out by ionising the working medium, extracting the positive ions, and accelerating them through an electrostatic field. Another method is to accelerate a fully ionised plasma in an electro-magnetic pump—probably a more efficient process.

SUBJECTS DISCUSSED AT THE SYMPOSIUM

" The Scientific Applications of Rockets and Satellites," by Professor H. S. W. Massey, F.R.S., Quain Professor and Head of Department of Physics, University College, London; " British Upper Atmosphere Sounding Rocket," by Mr. W. H. Stephens, M.Sc., deputy director, Royal Aircraft Establishment; " Some Propulsion Problems of High Altitude Rockets," by Professor A. D. Baxter, M.Eng., M.I.Mech.E., vice-principal, College of Aeronautics, Cranfield; "Design Problems of Large Rockets," by Mr. K. J. Bossart, technical director, Convair-Astronautics; " Re-Entry and Recovery," by Dr. W. F. Hilton, D.Sc., F.R.Ae.S., chief aerodynamicist, Sir W. G. Armstrong-Whitworth Aircraft Limited; " Dynamics of a Dissociating Gas Non-Equilibrium Theory," by Dr. N. C. Freeman, Ph.D., Aerodynamics Division, National Physical Laboratory; " Some Problems of Instrumentation, Telemetry and Guidance," by Dr. A. W. Lines, Ph.D., Guided Weapons Department, Royal Aircraft Establishment ; " The Earth Satellite Programme," by Mr. Milton Rosen, United States Naval Research Laboratory; " Current Picture of Research in Bio-Astronautics," by Dr. Hans G. Clamman, United States Air Force School of Aviation Medicine; " Psycho-Physiological Hazards of Satellite Flight," by Lieutenant Colonel J. P. Henry, United States Air Force; and " Future Developments in Rocket Propulsion Beyond the Atmosphere," by Dr. L. R. Shepherd, Ph.D., Atomic Energy Research Establishment.

DISCUSSION ON HIGH ALTITUDE RESEARCH

The discussions which followed were as interesting as the lectures which provoked them. Among the points raised was a plea that, in the excitement over rockets, the well-tried methods should not be neglected. For many investigations, suitable indirect methods are much cheaper than rockets: balloons can lift instruments to useful heights, and can stay there for many hours. The main aim of research on the atmosphere is an understanding of its evolution in time as well as space, which cannot be done well by rockets. From this aspect, satellites would be much more useful, but they would have to be virtually outside the atmosphere to last any length of time.

Development on the components of the Vanguard launching vehicle has reached a stage where a first-stage motor has been fired satisfactorily for 2,000 seconds, although only called on to fire in the vehicle for 142 seconds. When asked about the re-entry of the Vanguard satellite, Mr. Milton Rosen said that the magnesium alloy shell would melt, but some of the heavier components would, possibly, not vaporise but would shatter due to thermal shock. With a somewhat thicker skin, recovery of the satellite might be possible.

On propulsion problems, it emerged that a main obstacle to improved rocket-engine design is the lack of knowledge of the processes involved in combustion, heat transfer and the flow of hot gases. At present, in order to give satisfactory life, it is often necessary to sacrifice performance. As knowledge improves, it should be

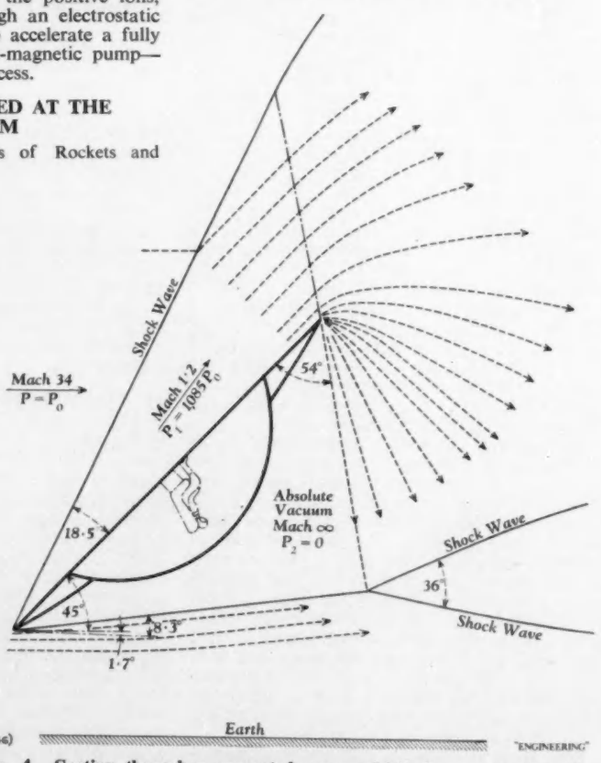

Fig. 4 Section through a suggested space vehicle for re-entry into the earth's atmosphere.

possible to improve specific weight by using a number of smaller engines. This would also save large expenditures on test facilities, which now tended to cost far more than the device being developed. Against the trend towards multiple small engines was the view of one speaker that a single large engine is to be preferred, even though less efficient, owing to the greater failure risk with a number of engines.

Dr. W. F. Hilton's paper on the re-entry and recovery of vehicles from outside the atmosphere was easily the most controversial presentation in the Symposium. Several speakers disputed the presence of an absolute vacuum behind the vehicle postulated by the lecturer, and suggested that the effects of viscosity and finite leading-edge radius might let air pass subsonically round the leading edge, and, far from having a vacuum, the pressure might be quite high; that in some tests at Princeton University in a helium tunnel at Mach 15, the pressure on the base of a model was several times that of the atmosphere; and that it is not safe to extrapolate data at fairly low Mach numbers to conditions at very high Mach numbers such as Mach 34.

This report may well be concluded by the summary given by one speaker of the motivation which lies behind the desire to find out what is outside the atmosphere or on the moon. Man's urge to find out about his environment is the inspiration of all scientific research, currently so evident in the I.G.Y. It may be necessary to point out to those who control the finances that mankind is now in the same state, as regards the exploration of space, as the navigators who first sailed across the Atlantic. They did not know of the presence of the New World, or of the vast resources of petroleum that it hid: even when they had discovered the land and its prizes, they were unable to exploit the petroleum for lack of knowledge of the internal combustion engine or of chemical technology. Untold possibilities lie ahead in this new field of research into the space which surrounds us.

ROCKETS AND SATELLITES ON SHOW

The Symposium at the College of Aeronautics on High Altitude and Satellite Rockets was accompanied by an exhibition which was devoted in greater part to showing the experiments and rocket techniques which will help to gain new scientific information during the I.G.Y. A Skylark rocket, developed by the Royal Aircraft Establishment, was on show: it was a complete vehicle which is actually to be fired at the Woomera range, and it was accompanied by a series of exhibits to explain the instrumentation, used by the British Universities and other workers, which will be installed in the forward part of the vehicle. Skylark is propelled by Raven, which is perhaps the largest solid-propellent rocket motor which has been made in this country, and the exhibit illustrated particularly well the way in which a well-designed solid-propellent motor can combine structural efficiency with simplicity.

The experimental techniques for measuring the properties of the atmosphere were highly ingenious: the method used by Imperial College to measure the movements of winds in the upper atmosphere by the use of a modified form of "window" was noteworthy. The strips of aluminised paper used to confuse enemy radar during the war has given way to small slivers of aluminium foil about 2 in. long, which act as resonant dipole reflectors for the high-frequency ground tracking radar sets. Large echoes can be received from very light targets, which descend slowly.

A working model showed the principle of the Grenade experiments to measure the velocity of sound in the upper atmosphere and hence to determine the temperature. The grenades were simulated by high-intensity sparks, and oscilloscopes showed how the time lag, between the flash and the noise arriving at the "ground," was reduced as the "atmosphere" in a heated glass tube became warmer. Cameras for recording the flashes by day and by night were on view. Other exhibits included a demonstration of the way in which sodium is vaporised in a thermite furnace and shot out into the air to glow by photo-excitation, and the Langmuir probe which is extended by a lazy-tong mechanism in front of the rocket, after the nose cone is blown off, to measure ionisation in the atmosphere. The airglow, which comes from great heights, will be measured by a set of photomultipliers looking forward in the rocket nose, while a sensitive microphone, installed in the vehicle skin, will detect the impact of micrometeorites. The explanatory exhibit was provided with a tin of fine sand which could be sprinkled on the skin surface; every grain made a blip on an oscilloscope screen, even when dropped from about an inch above the surface.

The French sounding rocket Veronique was on show: a sectional model of this vehicle showed that French workers are no less ingenious than Britons and Americans, particularly in obtaining satisfactory solutions to difficult problems with simple devices. The vehicle is propelled by an 8,000 lb. thrust rocket engine, using fuming nitric acid as the oxidant with either 85 per cent. gas-oil/15 per cent. furfural alcohol or turpentine as fuel. These fuels are self-igniting with nitric acid, which saves the use of separate ignitors. The combustion chamber is fairly conventional: it has a double wall construction, the nitric acid passing through the gap between the walls as a coolant, and the injector exhibits rows of holes for impinging fuel and oxidant jets. Propellent supply is by a gas generator, which uses small separate tanks of the main propellents, the combustion products being cooled with a solution of ammonium nitrate in water. Since the vehicle is launched vertically, no elaborate bags or pistons are needed to keep the propellent from sloshing and entraining gas pockets on their way to the combustion chamber.

The body of Veronique is made from welded light-alloy sheet, the tanks being integral. The forward portion of the vehicle is demountable, and contains the instrumentation and a recovery parachute. Stabilisation is provided during flight by triangular fins, made of wood with light-alloy skinning, but stability at launch is given by a set of wires from the fin tips which are attached to spools on a simple pad-type launcher. These wires maintain the rocket pointing directly upwards until the velocity is high enough for the aerodynamic forces to be adequate, after which they are automatically disconnected. Veronique reached an altitude of 85 miles in February, 1954.

An impressive combustion chamber for a large liquid-propellent rocket engine was shown by the Royal Aircraft Establishment, Westcott. It was made of hydroformed stainless-steel strips welded together; the combustion space was roughly spherical, and was integral with the divergent nozzle. No thrust rating was quoted, but the throat diameter was about 9 in., the exit diameter about 24 in., and the overall length nearly 4 ft.

The Department of Aerodynamics of the College showed some of their experimental facilities which might be of use to rocket flight. One of the most fascinating exhibits, developed by Mr. G. M. Lilley, was a high pressure-temperature converter, which used the techniques of the shock tube to produce a fairly small-volume stream of very hot air by blowing a supersonic stream of air at normal temperature against the mouth of a tube restricted at the far end. The reflected shock system in the tube can produce a stream of gas from the orifice at the far end which, for a stagnation pressure of 100 lb. per sq. in., has a temperature of 500 deg. C. If the stagnation pressure were raised to 3,000 lb. per sq. in., the temperature achieved should be in the order of 3,000 deg. K. In view of the great expense and difficulty which attend the construction of test equipment for use with hot high-speed streams of gas, such techniques would appear to be well worth exploiting.

Obituary

DR. R. W. L. GAWN

It is with deep regret that we record the death, on July 10, of Dr. Richard William Lewis Gawn, for 19 years the Superintendent of the Admiralty Experiment Works at Haslar, and a Vice-President and Chairman of Council of the Institution of Naval Architects. Dr. Gawn, who was 63 years of age, underwent a major operation early this year which prevented him from attending the Spring Meeting of the Institution of Naval Architects to receive the award of the first William Froude Gold Medal of the Institution; but he was then stated to be making good progress towards recovery. To many of the members, therefore, who were unaware of his subsequent relapse, the news of his death will be the more deeply felt for being unexpected.

Dr. Gawn, who received his degree of Doctor of Science, *honoris causa*, from the University of Durham in 1953, was born in Portsmouth on December 30, 1893, and was educated in the Dockyard School. He was apprenticed in the Dockyard as a shipwright, passing out with distinction in 1916 and being appointed at once to the Royal Corps of Naval Constructors.

In 1919 he was appointed to assist the late Mr. M. P. Payne, then Superintendent of the Admiralty Experiment Works at Haslar; his first contact with the establishment over which he himself was subsequently to preside as Payne's successor. He spent five years there before returning again to the Admiralty; but he was not long away from tank work, for considerable extensions to the equipment at Haslar were under consideration and in this preparatory work Gawn took a prominent part. Visits to Germany, France, Austria and Italy, to study current experiment-tank practice in those countries, provided valuable guidance for his work on the new Haslar tank, which was completed in 1932; and it was a natural development that, on Payne's retirement in 1938, Gawn was appointed to succeed him.

The list of the subjects of which he made special studies during his 19 years in that position is a long one and, even so, must be incomplete for reasons of national security. In addition to the usual problems of ship resistance and propulsion, of both surface and underwater craft, it included vibration, the design of propellers, mines, anchors, and—perhaps his most important field of specialisation—the study of cavitation, which led to the construction at Haslar of two large cavitation tunnels and to his appointment, by the International Towing Tank Conference, as chairman of the International Committee on Cavitation. As an outcome of his work on submarines, he became interested in the form and self-propulsion of fishes and whales, and contributed to *Nature* an article "The Locomotion of Whales," which attracted considerable attention.

Dr. Gawn was elected to the Council of the Institution of Naval Architects in 1940, became a Vice-President in 1953, and was appointed Chairman of the Council in 1956. He was also the first President of the Southern Joint Branch of the Institution and the Institute of Marine Engineers. His work received Royal recognition when he was made an O.B.E. in 1947, followed by the C.B.E. in 1955.

★ ★ ★

MR. JULES MENKEN

Mr. Jules Menken, who contributed several articles to ENGINEERING in recent months, died on July 20. He achieved what *The Times* described as "an envied reputation as a writer on world affairs and problems of defence." Early this year we invited him to help in elucidating the inter-relation between the military approach to defence and the scientific approach, which he did with considerable skill. He had a remarkable capacity for swift, direct thinking which also, in personal relationships, showed itself in a lively attention to everyone he met.

WHY WAS GEORGE STEPHENSON NOT A MEMBER OF THE "CIVILS"?

Samuel Smiles, in his *Lives of the Engineers*,* says that George Stephenson (1781-1848) wished ". . . to be admitted to the membership of the Institute of Civil Engineers, the chair of which his son afterwards so ably filled. But there were two obstacles to George's admission to the Institute: the first was that he had served no regular apprenticeship as an engineer; and the second was, that he should go through the form required of the youngest member of the profession, and fill in a paper detailing his experience, to which he must afterwards obtain the signatures of several members of the Institute, recommending him personally and professionally for election. He could not comply with the first condition, and his son strongly recommended him not to comply with the second. The Council of the Institute were willing to waive the former, but not the latter point. Probably he thought that it was too much to ask of him that he should undergo the probationary test required from comparatively unknown juniors, and state his experience as an engineer to a society many of whose members had been his own pupils or assistants. . . . As it was, he turned his back, though reluctantly, on the Institute of Civil Engineers, and accepted the office of President of the Institution of Mechanical Engineers at Birmingham. . . ."

R. H. Parsons goes further in his *History of the Institution of Mechanical Engineers*.† "The story goes," he writes, "that one afternoon in 1846 a group of railway engineers were watching locomotive trials on the Lickey Incline at Blackwell, near Bromsgrove on the Bristol and Birmingham line. It started to rain heavily and the party took shelter in a platelayers' hut, where the discussion turned on the refusal of the Council of the Institution of Civil Engineers —then a society of about 600 members—to admit George Stephenson. . . . As an outcome of the discussion it was felt that the time had come for mechanical engineers to have an Institution of their own. . . ."

Such is the picture of the celebrated engineer and his relations with the professional institution painted by two biographers; it has also been repeated elsewhere, and has never before been challenged. An investigation made recently has, however, thrown a different light on the subject. The findings of this investigation have been drawn up in the form of a report, of which the present article is an abridgment.‡

Thomas Telford, the first President of the Institution, was the son of a shepherd in Scotland. To become a member of the Institution, George Stephenson, the pit mechanic's son, had only to find three members to sponsor him, and to agree to the condition of either writing each year a paper for the Institution or more simply providing them with some document or article of engineering interest which they did not possess. As early as 1830 his son Robert fulfilled these conditions and was introduced to the society by Telford himself. Everything about the available evidence goes to prove that it was George Stephenson himself who refused to join the Institution, and but for a lack of care in wording, current at the time, we have his own evidence for this.

TELFORD'S DISAPPROVAL

Ignoring this evidence for the time being, the question which perplexes is whether there would have been room in the same Institution for both Thomas Telford, the great engineer of canals and roads, and George Stephenson, the prime architect of the new railway age of which Telford undisguisedly disapproved. The answer is probably "yes," at least in the early days and certainly up to 1827. This was a year in which the young Institution had only about 130 members and was still struggling to gain recognition among engineers. By then George Stephenson had invented his safety lamp, had completed the Stockton and Darlington Railway, and was building his railway across Chat Moss. A corresponding member of the Institution was Robert Bald, an old friend from Edinburgh; a full member, James Walker, who Stephenson had described as his only friend in the engineering world at the time when he was looking for support for his first Bill in Parliament; an associate member was George Bidder who, despite being a pupil of H. R. Palmer, was his son's closest friend at the University.

Although it was by no means yet the custom for the great engineers of the day to belong to the Institution, and many disapproved of Telford having accepted the presidency, there is no reason to suppose that George Stephenson was at this time excluded. There is, however, reason to believe that he was not kindly disposed towards the most energetic of the founder members, H. R. Palmer, who, with Francis Giles, had played so active a part against him in Parliament. Smiles said of him* "If he was occasionally impatient of the opposition of his professional brethren, it is scarcely to be wondered at when we look at the simple earnestness of his character, and consider that his sole aim was the establishment of his own well-founded convictions. No wonder that he should have been intolerant of that professional gladiatorship against which his life had been one prolonged struggle. Nor could he forget that the engineering class had been arrayed against him during his arduous battle for the locomotive, and that but for his own pluck and persistency, they would have strangled it in its cradle." In 1829, when Telford submitted a report critical of Stephenson's work on the Liverpool and Manchester line, Stephenson was probably neither endeared to the man nor inspired to become a member of the Institution of which he was President.

In 1835 Telford died and James Walker became President of the Institution, which then had 250 members. He, too, in his battle for the stationary engine, was to fight against Stephenson in railway matters, although in 1844, the last year of his presidency and a year when Francis Giles was a member of Council, Walker was to use the following words in his annual report: "The time of the eminent railway engineers has been for some years so absorbed by the establishment of the principal lines of the Kingdom, as to preclude their assisting in the duties of the Institution. They now hope to do so and to give every aid in extending its activity."

In 1845, John Rennie, Stephenson's old adversary, became President of the Institution, and he gave signs that some of the fires of past controversies had died when he acknowledged the work of George Stephenson in his presidential address. It was a speech which reviewed the whole history of civil engineering and was remarkable in that it did not award Telford a place higher than that of many another engineer. This period and the last year of Walker's presidency, when the Institution had just under 600 members, are of particular importance in the study of the alleged slight to George Stephenson by the Institution, especially as from 1844 onwards Robert Stephenson was a member of Council. Are we to believe that the devoted son was to acquiesce in the refusal of his fellow members of Council to grant the whim of an ageing and nationally respected father?

Just as a study of the 1820's and 1830's makes clear the vigour with which professional jealousies were pursued among engineers, so a study of the 1840's shows that the engineers involved were beginning to find personal conflicts wearing. The Institution of Civil Engineers was expanding rapidly at this time, and becoming a common meeting ground, and we find bitter professional adversaries discussing dispassionately matters of mutual interest. In 1856 Robert Stephenson paid tribute in his presidential address to the conciliatory work of the Institution, in a passage which occurs a few sentences after one in praise of his father's works. It seems inconceivable that had there been the slight to his father which has been suggested he should have recalled his father's memory so shortly before pronouncing the following words: "There was a time . . . when the spirit of rivalry among civil engineers was carried so far as to occasion some feelings of estrangement. I am happy to think that these feelings have given way to more friendly and confidential relations amongst us; that our intercourse is now characterised by mutual forebearance and conciliation; and that if rivalry does exist it is no longer entertained in an unbecoming spirit. . . . To this Institution, and to the opportunities afforded by the meetings, we are mainly indebted for this improved spirit."

George Stephenson's own evidence could have saved all misunderstandings but for vagueness in wording. On February 27, 1847, he wrote to J. T. W. Bell: "I have received yours of the 23rd inst. In reply to it I have to state that I have no flourishes to my name, either before it or after, and I think it will be as well if you merely say Geo. Stephenson. It is true that I am a Belgian Knight, but I do not wish to have any use made of it. I have had the honour of Knighthood of my own country made (? offered) to me several times, but would not have it; I have been invited to become a Fellow of the Royal Society; and also of the Civil Engineers Society, but I objected to these empty additions to my name. I have however consented to become President to I believe a highly respectable mechanics' Institute at Birmingham." To many people there will be as little doubt that Stephenson was referring to the Institution of Civil Engineers as that he was referring to the Institution of Mechanical Engineers.

In those days the Institution was considered to be a "society," and the words occur frequently in both the correspondence and the minutes of the time. William Tooke, Rennie's solicitor, wrote a letter on November 13, 1830, to "The Society of Civil Engineers." Yet it will be noted that Stephenson wrote "the Civil Engineers Society," which is an additional reason for

* *Life of George Stephenson*, 1857, p. 502.

* 1862, vol. 3, pp. 479–480.

† 1947, p. 10.

‡ Limited supplies of the unabridged report are obtainable from the Institution of Civil Engineers, Great George-street, London, S.W.1.

believing that he was not referring to the Smeatonian Society of Civil Engineers. Why, in any case, would people such as Donkin, Roget, and the Rennies, who were Presidents of the exclusive Smeatonian Society of Civil Engineers, request him to become a member when they did not, if we are to believe Smiles, permit him to become a member of the Institution in which they were also influential?

STEPHENSON'S PORTRAIT

Finally, comes additional material which may help to expose the alleged slight as a fantasy. At the Conversazione of 1848 the Institution planned a singular tribute to the great engineer. It decided to exhibit John Lucas's latest portrait of Stephenson standing on Chat Moss (reproduced opposite), and Robert Stephenson expressed his unqualified approval of the action.

In these circumstances, it is less surprising that Joshua Field devoted almost all his address at the annual general meeting at the beginning of 1849 to George Stephenson's death: "The obituary records the decease of several valuable Members, whose loss will be greatly felt. In addition to these gentlemen, the profession has lost another, who was considered a veteran and a hero in its ranks; I allude to Mr. George Stephenson, whose career could not be noticed in the Report, because he was not a Member of the Institution; he was, however, well known to us all, and not infrequently joined in our discussions." The speech which followed has no savour of hypocrisy. A great engineer had died, who was a familiar figure at his son's office in Great George Street and at the Institution, and it was just that although he had refused to become a member he should receive a fitting tribute.

[Editorial comment will be found in the leading article on page 97 of this issue.]

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Letters to the Editor

USING CONSULTING ENGINEERS

SIR,—I have just returned from abroad and seen in your issue of June 28 an excellent article entitled "A User's Critical Comment" referring *inter alia* to the paper that Mr. Ovens and I read at the British Electrical Power Convention.

I am in full agreement with the comments made except that your correspondent does not carry his argument to its logical conclusion about the methods in which industrial projects may be engineered. He suggests that the only way that industrial concerns can obtain appropriate technical advice is by increasing their engineering staff or forming development departments. This may be the best way where the organisation is sufficiently big to be able to retain high-class specialists in all the different branches of engineering and where the amount of development shows little variation year by year. But, in other cases, it seems clear that the work can be done more economically and with the background knowledge of an organisation of much wider experience if consulting engineers with the right specialist experience are employed. This way of engineering a project has the further desirable effect of making the best use of our very limited supply of fully trained engineers.

Yours faithfully,

HENRY CLAY.

32, Victoria-street,
London, S.W.1.
July 19, 1957.

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MACHINE FOUNDATIONS

SIR,—In Mr. A. S. Bythway's letter, published on page 70 of your issue of July 19, he refers to the possibility, in many cases where resilient mountings are used, of standing machines on the floor without bolting them down. I agree with him that this is usually quite in order for self-contained machines; those of which I have most experience being motor-generator sets. These show no tendency whatever to move about. I do not know whether the same could be said of machines with large pulsating or oscillating forces, such as presses, but it is possibly true for them also when they are fairly symmetrical. As Mr. Bythway points out, the absence of holding-down bolts permits a flexibility of layout which may be very advantageous. However, I have encountered considerable opposition from maintenance and erection engineers who insist on the old method of bolting down.

Yours faithfully,

A. J. KING.
Research Department.
Metropolitan-Vickers Electrical Co. Ltd.,
Manchester 17.
July 22, 1957.

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Weekly Survey

Cover Picture: *With the increasing cost of fuels, great strides have been made in the manufacture of furnace refractories and, more particularly perhaps, of heat-insulating materials. The illustration shows the brickwork for a batch-type electric furnace in course of erection.*

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Chasing Shadows

The Labour Party's policy statement on public ownership is a bewildering document. Little that emerges is concrete and yet much of what is said could be interpreted as a threat levelled at those people who run British industry. *Industry and Society* seeks to define the social responsibilities of industry and blandly asserts that they cannot be fulfilled by industry as it exists to-day. The Party's solution is a large measure of public ownership. This would apply particularly to large firms, and possibly also to whole industries—none is named—where there is a "shortage of capital, poor management or bad industrial relations."

The main peg of the policy of public ownership outlined in the report is what is called "the emergence of the large firm." Examples are quoted of large concerns who prospered under public ownership, such as Volkswagen in Germany, the Steel Company of Wales, and Renault in France. The report recognises that "the size of such firms is substantially determined by economic and technological developments" and that "managerial control is an inescapable consequence of the complexities of technology and modern business administration." Yet public ownership is advocated, seemingly because it would help to ensure that the large firms discharge their responsibilities "to maintain employment and to raise living standards," and, more particularly, because it helps to promote the levelling down process the Party calls social equality.

Basically the suggestion that the large firm, the industrial leader, should be publicly owned is designed to provide a Labour government with the power to plan the economy's development. It is easier and less dangerous than to nationalise whole industries, though the possibility of this is not excluded. The fact that since the war the number of "private companies" has increased by 100,000 to 280,000, while that of public companies has declined by 2,000 to 11,000, suggests that private enterprise remains very much alive in the United Kingdom. It is the nature of our tax laws, and also the wish to invest in something where one's own efforts can affect progress, which have dictated the structural change. To legislate against this would be a dangerous thing to do. To purchase successful large firms is a strangely pointless thing to do unless it be to prove (on near-infallible grounds) that nationalised undertakings can be profitable.

To the Pure . . .

So far as the Labour Party is concerned, the nationalised industries are like Caesar's wife—above reproach. The latest pamphlet on nationalisation, put out under the title of *Public Enterprise*, will be debated at the annual conference of the Labour Party at Brighton in October. Judged by any except party standards the document is a depressing one. Like all political tracts, it has its fair share of half-truths and rubbish. The best that can be said for it is that on the one hand no other political party might have done a great deal better (though the point of view would have been quite different) and, on the other hand, it is harmless enough in its way as it goes forward to the Brighton conference.

The pamphlet has tried to do a great many things in its 59 pages. It must have something in it for the extreme left wing, it must pay respect to the constructive views of influential people in the Party, it must not offend the trade unions and it must make occasional swipes at the Conservative Party. The result has been to write a case for the nationalised industries which the chairmen of the boards concerned could not have bettered. There are then at least a few generalisations on such vital issues as management problems, consumer interests, labour relations and public accountability. Oddly enough the best section, so far as it goes, is on economic and financial policy.

Nothing is to be gained by uninformed and indiscriminate criticism of the nationalised industries. They have done good work in many respects against great difficulties. On the other hand, little is achieved by praise as fulsome as this. The fact is that the technical, managerial and financial problems of the big basic industries are not to be solved at the political level except as regards the very broadest issues of policy. This pamphlet will move only the doctrinaire readers on the left and on the right. Other readers will finish it in the same manner as no doubt the more level-headed of its sponsors finished writing it—with a sigh of relief that it is over.

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Viva il Mercato Comune!

The Italian Chamber of Deputies has now ratified the Treaty of Rome which seeks to establish the European Common Market. The parliamentary exercise on this subject has been more enthusiastic in Italy than in Germany or France. Although it might be overstating the case to say that the Italians welcome the Common Market with glee, at least they view it with the ebullient Italian substitute for sober satisfaction. It is not going too far to say that at the moment the participation of Italian industry in the European Common Market (and in due course possibly the Free Trade Area) is viewed in western Europe with the same misgivings which were accorded to Germany when the idea of a common market was first seriously mentioned two years ago.

This changed attitude about Italy's position is prompted by a number of considerations. First of all, the Italian steel industry has prospered much more under the Iron and Steel Community than even the optimists dared hope for. Then again, Italy has lost its colonies and many of its trade connections and is therefore prepared to begin afresh under the stimulus of some form of European federation. The Italians have spent dollars on new equipment and management training which, allied to their traditional engineering skill, is achieving results which have surprised even the protagonists of American investment and management techniques. There is a pool of unskilled unemployed labour in southern Italy on which the northern industries can draw and there is even a certain amount of skilled and professional engineering labour seeking employment—a fact which has already attracted the attention of certain engineering companies in this country. The large and

influential Montecatini company has already said that it looks forward to enjoying a European market in which to operate instead of the limited Italian economy. Competition in motor cycles and sewing machines is also severe. Italy has the advantage of low wages and a lighter burden of social charges than most other countries in the European Common Market. Altogether, there is some prospect that in certain products at least the Italians will come and see and conquer.

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Colvilles Grow

A four-year expansion programme at an estimated cost of £32 million is to be put in hand immediately by Colvilles, the Glasgow steel group. The new work will begin within a few weeks of the completion of an earlier programme which has cost £25 million for their new steel-making plant at Ravenscraig; there, the No. 1 blast furnace is expected to be lit not later than early August, for the coke ovens have now been warming up since the first week in June.

The new programme centres on the commissioning of a second blast furnace and associated coke ovens at Ravenscraig in 1960, when the Scottish Area Coal Board reckon that the necessary annual supply of half a million tons of coking coal will be available locally. Allied with this will be a new slabbing mill to replace that at the adjacent Dalzell Works, allowing plate output there to increase to 6,000 tons weekly; at Clydebridge the plate mill is also being enlarged to handle 7,000 tons a week, an increase of 2,000 tons weekly. Altogether, Colville's plate output will grow by a third to 800,000 tons annually. At their Hallside Works, a modern alloy billet plant is being completed by the end of 1958. Ore handling has been rationalised by the development of new facilities on Clydeside so that it will be possible to unload two vessels simultaneously and get a 1,000 ton train away in 40 minutes. In all this work, extensive use has been made of push-button control and instrumentation generally, so that a substantial increase in steel output will be obtained without a material change in the labour force of 18,600 which is now employed by the group.

Announcing these many developments, Sir Andrew McCance, the company's chairman and managing director, pointed out that apart from an important export trade all the group's output was and will be used locally. He mentioned particularly the new works for the Caterpillar Tractor Company, who will be taking a large part of the special steels from Hallside and steel castings from the group's subsidiary, the Clyde Alloy Steel Company, where the capacity is being raised to 13,000 or 14,000 tons per annum.

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The Loch Awe Project

The largest hydro-electric project yet undertaken by the North of Scotland Hydro-Electric Board was announced last week. This scheme will utilise the flow from 324 square miles of the catchment area of the River Awe and includes provision for the construction of the first large-scale pumped storage hydro-electric development in Scotland. The total installed capacity will be about 450 MW and it is expected to cost £24·5 million.

The development is to be in three sections—Inverawe, Cruachan and Nant. Of the three the Cruachan section will be the largest by far, accounting for 400 MW of capacity. This is accounted for by the fact that this section includes the pumped storage plant. This scheme is thus not only the largest of its kind in the Highlands but also is to be integrated with the electricity load on steam and atomic power stations. Provision of a reservoir for the scheme may yet be a critical factor in hydro-electric installations, for Argyllshire has suffered from a lack of water before now.

No date has been fixed for the commencement or completion of the work. The scheme will be integrated with the country's generating programme but clearly the first beneficiaries will be the industrial area of Clydeside some 60 miles to the south-east. An undertaking has been given that the surrounding land will not be affected by flooding, which will preserve the fishing in the River Awe and the amenities in and around the Pass of Brander. The ancient preserves of the Clan Campbell are clearly not to be submerged by the mere requirements of electric power !

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Engineering Customers

Averages generally mislead, especially when it is the exceptional company which is being considered. No-where is this better illustrated than in the statistics of capital spending by industry published by the Board of Trade. The figures for the first quarter of the year show a rise of 13 per cent. above the first quarter of 1956, which is in fact far less than is being spent by the leading companies in the industries concerned. Chemicals, paper and textiles all show a reduction in their index of capital expenditure. Yet the annual reports of Albert E. Reed, the paper producers, and of Courtaulds, who produce most of the country's rayon (they have recently acquired British Celanese) suggest that the rate of expansion is in fact much greater, though trading conditions are less favourable.

Albert E. Reed's chairman, Lord Cornwallis of Linton, spoke of "consolidation of the group's extensive interests against a background of less favourable trading conditions." Considerable investment has taken place in new machinery, throughout the paper industry, and Lord Cornwallis warned that a stage might be reached when paper production capacity overtook demand. The total capital employed by the group increased from £15 million in 1954 to £41 million in 1957, of which £24 million consisted of fixed assets.

Courtauld's chairman, Sir John Hanbury-Williams, reported a sharp fall in trading profits, by 17 per cent., but was at pains to emphasise that the group must conserve their resources "to ensure that all our plants and processes are up to date, and where necessary to expand our interests at home and abroad." For them, difficult trading conditions are an additional reason for spending money on plant and equipment, not the reverse.

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Lucky 13?

During the first quarter of this year capital expenditure by manufacturing industry went up by 13 per cent. on the same period of 1956. This compares with an increase of 29 per cent. in the first quarter of last year and with 17 per cent. in the last quarter of the year. The increase is therefore much smaller than over the same period of 1956 but it is higher than was anticipated about a month ago when a provisional estimate of 10 per cent. was made. The latest figure is the revised one published by the Board of Trade in its regular analysis of the capital expenditure of 600 public companies.

Expenditure both on building and plant and machinery rose by 16 per cent., but this was offset by a severe drop in spending on vehicles. The first quarter of the year was affected by petrol rationing which severely reduced the sale of all types of vehicle. Since then there has been a big increase in vehicle output and this will certainly be reflected in a big increase in capital expenditure in the second quarter of this year.

So far as spending by individual industries is concerned, the biggest outlay compared with the same period of last year was in iron and steel. At 47 per cent., outlay by the steel industry was more than double the average increase of 1956. The chemical industry maintained last year's average of about 36 per cent. The most abrupt change for the worse came in the large engineering and shipbuilding groups where capital outlay was 7 per cent. lower than in the same period of last year. Motor vehicles also showed an easing-off but this is partly because the long-term expansion programmes of some of the large companies are now reaching their final stages.

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Standard Purchaser

The offer by Massey-Harris-Ferguson of £10·5 million for all the ordinary stock of the Standard Motor Company is likely to be accepted. It will complete a process begun in June last year when Massey-Harris-Ferguson acquired through their "mystery buyer" over 18 per cent. of Standard's total equity, sufficient for effective control. Lord Tedder, chairman of Standard, described the offer as a "natural development from our present association."

For some years now Standard have been in difficulties with the car side of their business. The mainstay has been, and is now even more markedly, the production of the Ferguson tractor, under their agreement with Massey-Harris-Ferguson. The new automated tractor plant, which cost some £4½ million, is said to be one of the most modern and efficient in the world. It is unlikely to have its equal in Western Europe. Massey-Harris-Ferguson are known to want to concentrate more of their manufacturing in this country and the manufacturing facilities available at Standards are a focal point in the group's British plans.

Whether or not Massey-Harris-Ferguson will retain the car side of the business is open to doubt, though Lord Tedder's message to Standard's shareholders mentioned that "full weight would be given to car production." The odds appear somewhat in favour of a deal with one of the existing car manufacturers.

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Agricultural Machinery Prospects

The latest figures of output of agricultural machinery, for the fourth quarter of 1956, suggest that output had continued to decline. This was particularly marked with market garden tractors and ploughs; exceptions were combine harvesters, potato spinners and milking machines. The annual report of Rotary Hoes Limited suggests that the difficult trading conditions of 1956 in the home market were due mainly to credit restrictions on dealers and on the farmer himself. Mr. E. N. Griffith, chairman and managing director, expressed some apprehension concerning what he called "the chain reaction" to constant wage increases, but said that 1957 trading was much improved and that "there are no signs yet to indicate a persistent decline such as occurred in June last year."

Ransomes, Sims and Jeffries share Mr. Griffith's apprehension concerning the effect of wage increases on overseas markets. Their chairman, Mr. Reuben J. Hunt, refused to forecast the company's results in 1957, saying that the latest wage increase "made it more difficult for us to trade, especially overseas." His warning that "some of our overseas markets for agricultural machinery may be permanently lost" suggests that wage levels in this country have risen sufficiently to make the production of some products more economical in the overseas markets concerned. This is a trend which has affected the nature of British engineering exports since the beginning of the century and which must go on as we increase our standard of living in relation to that of our main customer countries. The remedy, mentioned by Mr. Hunt, is "to vary our product so that we need not depend so largely upon a class of machinery which cannot support a high wage structure."

ENGINEERING FIRMS IN THE FREE TRADE AREA

5—" PECHINEY "

(*Cie. de Produits Chimiques et Electrometallurgiques*)

With a record trade deficit in 1956 of Fr. 413,325 million (£413 million), France is faced with the need for a radical overhaul of her economy, if her industries are to play their full part in the European Economic Community. At the beginning of 1957 France was one of the countries which had made least progress in trade liberalisation in spite of the fact that a number of steps in that direction were taken in the three years 1954 to 1956. On January 1, 1957, however, some 17·7 per cent. of total imports were still subject to import quotas, and special compensatory taxes had been imposed on many of the liberalised imports. In June, 1957, the decision was taken to suspend the liberalisation measures agreed with other members of O.E.E.C. and to re-impose import quotas.

The sharp rise in the trade deficit has been due mainly to the rapid expansion of French industrial output over the last three years coupled with inability to expand exports to the extent necessary to pay for rising imports of fuel and raw materials. French exports have hitherto consisted mainly of raw materials and semi-finished products, bulk foodstuffs and the simpler manufactures such as textiles. If stagnation, and possible decline, in industrial production is to be avoided means will have to be found to expand exports of the higher cost agricultural products and the more highly finished industrial goods, including the products of the engineering and chemical industries. In this task companies such as Pechiney (Cie. de Produits Chimiqueset Electrometallurgiques), which is important in both the metallurgical and chemical fields, have an important part to play. In the field of aluminium production, in particular, France has great advantages in the availability of cheap hydro-electric power and adequate reserves of bauxite. Besides being the largest producers of aluminium in Europe, Pechiney are the leading French producers of polyvinyl chloride and are also important producers of heavy chemicals and insecticides.

Owing to the difficulty of obtaining yearly production and sales figures and to the fluctuations of the French currency over the past 20 years, it is not easy to assess the growth and development of Pechiney over that period. The consumption of electricity, however, gives a good indication of the growth of the company: this rose from 1,114 million kWh in 1938 to 3,500 million kWh in 1956. The share capital has risen between 1951 and 1957 from Fr. 17,000 million to Fr. 26,000 million. About 63 per cent. of the turnover in 1953 was accounted for by aluminium and aluminium alloys and 37 per cent. by chemical products.

Export of all products represented in 1956 20 per cent. of the company's output, against 22 per cent. in 1955 and 32 per cent. in 1953. The main export countries were the United States, the United Kingdom and Belgium. While there has been a sharp fall in French exports of aluminium to the United States and to the United Kingdom, the main reason for declining exports has been the marked rise in French internal demand. In 1956 this rise amounted to 16 per cent. and in order to ensure adequate supplies to French consumers it became necessary to suspend import duties for a little over a month at the end of 1956. During this period France imported about 6,000 metric tons of aluminium. In 1956 about 85 per cent. of the French output of aluminium was accounted for by Pechiney and Table I shows the rise of production of the Pechiney plants over the last 18 years. The only other producer of aluminium in France is the Ste. d'Electrochimie, d'Electrometallurgie et des Acieries Electriques ("Ugine").

Thus the production in 1956 was nearly 3½ times that of 1938 and France was in 1956 the biggest aluminium producer in Western Europe, followed closely by Western Germany.

The export of raw aluminium from France declined between 1953 and 1956 by 66 per cent. The share of the United Kingdom fell from 25 per cent. of the total exports in 1953 to 2 per cent. in 1955. The United States took in 1953 32 per cent. of the total exports but ceased to buy French aluminium in 1955. Belgium's share, however, rose from 25 per cent. in 1953 to 51 per cent. in 1955 and Sweden's from 5 per cent. in 1953 to 30 per cent. in 1955. No figures classified by countries are yet available for 1956.

TABLE I.—*Aluminium Production by Pechiney*

1,000 metric tons		1,000 metric tons	
1938	38	1951	75
—	—	1952	87
1947	52	1953	92
1948	44	1954	99
1949	50	1955	108
1950	50	1956	127

TABLE II.—*Aluminium Production of West-European Countries in 1956.*

	1,000 metric tons	Per cent.
France	150·0	25
Western Germany	147·4	24
Norway	92·7	15
Italy	63·7	10
Austria	59·4	10
United Kingdom	26·0	4
Other countries	70·8	12
Total	610·0	100

TABLE III.—*France: Export of Raw Aluminium*
(1,000 metric tons)

	1953	1954	1955	1956
Total	38·6	16·7	22·3	13·2
of which to				
United Kingdom	9·8	0·7	0·4	—
Belgium	9·8	3·7	11·3	—
Sweden	2·0	4·9	6·7	—
United States	12·2	1·5	—	—
Other countries	4·8	5·9	3·9	—

BAUXITE RESOURCES

With the exception of France, and to a less extent Italy, production of aluminium in Western European countries is dependent on imports of bauxite or alumina. The strong position enjoyed by the French industry is shown by the fact that French production of bauxite in 1956 amounted to 1,493,000 metric tons out of a total Western European production of 3,122,000 metric tons, the other main producers being Yugoslavia (791,000 metric tons), Greece (484,000 metric tons) and Italy (326,000 metric tons). The French production of bauxite would, in fact, be sufficient for an output of between 250,000 and 370,000 m. tons of aluminium, but further expansion of the aluminium industry is limited by the availability of hydro-electric power. France is therefore a large exporter of bauxite, mainly to Germany and the United Kingdom. In 1956 total exports amounted to 325,200 m. tons against 351,200 m. tons in 1955, in which year Germany took 206,800 m. tons and the United Kingdom 125,900 m. tons. The favourable position of the French industry is shown by the fact that the French price for aluminium (exclusive of taxes) is the lowest in the world. At the end of January, 1957, for example, it was equivalent to £180 per long ton compared with £197 per ton in the United Kingdom, £200 per ton in the United States, £202 in Germany and £232 in Italy. The French price was increased in March, 1957, by about £3 per ton in order to assist the industry to develop production in the Cameroons, and a further temporary rise of £1 per ton occurred at the beginning of July in order to compensate for the higher price of Cameroons, metal which is imported into France at the world price. Even so, the French price remained well below that in other countries.

Although, as stated above, the possibilities for the expansion of aluminium production based on hydro-electric power are limited, Pechiney are negotiating with the Ste. Nationale des Petroles d'Aquitane and Electricité de France for the purchase of natural gas and the erection of a power station based on natural gas in the region of Lacq. It is thought that this may permit the erection of a further aluminium reduction plant. For the rest, Pechiney are not confining their interests to France alone and have been largely responsible for the initiation of important development schemes in French African Territories and are also interested in the Inga project in the Belgian Congo.

In the Cameroons Pechiney-Ugine have an 82 per cent. interest in the Cie. Camerounaise de l'Aluminium Pechiney-Ugine (Alucam) which in February, 1957, started production of aluminium at Edea near the port of Douala. Output is expected to be about 10,000 tons in 1957, rising to 45,000 tons when the plant is completed in 1959. In French West Guinea and Equatorial Africa the Pechiney-Ugine group are participating in two international study groups which were set up at the end of 1955 to plan the construction of hydro-electric power stations and aluminium plants. The other participants are Vereinigte Aluminium Industrie A.G. of Bonn, the Italian Montecatini Company, the Aluminium Company of Canada and the Swiss Aluminium Industrie A.G. It is planned to build hydro-electric power stations and alumina and aluminium plants on the rivers Konkoure (French Guinea) and Kouilou (French Equatorial Africa). The deposits of bauxite in French Guinea are estimated to be as high as 1,000 million tons and are also to be exploited by the Aluminium Company of Canada, through their subsidiary the Ste. des Bauxites du Midi, for the production of alumina for export to Canada.

Projected developments on the Konkoure river include an alumina plant at Conakry with a capacity of 480,000 metric tons to be run by the Fria Cie. Internationale pour la Production d'Alumine, in which Pechiney-Ugine hold 23 per cent. of the capital, the other participating groups being the U.S. Olin-Mathieson Chemical Corp., the British Aluminium Company, Limited, and the Swiss Aluminium Industrie AG. Pechiney-Ugine will be in full control of the day-to-day running of the company and have a majority on the Board. At a later stage it is planned to expand production still further by the erection of a hydro-electric plant at Souapiti with an annual capacity of 3,000 million kWh and a second alumina plant with a capacity of 150,000 tons. Plans for development in the Belgian Congo are of a longer term nature and are based on the development of hydro-electric power at Ingo where the potential is about 200,000 million kWh per annum. The Belgian Syndicate originally responsible for these plans has been joined by the Afral development company in which the Pechiney-Ugine group is interested.

Besides aluminium, the metallurgical interests of Pechiney include the production of ferro-alloys, of titanium by the Kroll process and of copper-beryllium alloys. The company is also working on zirconium and aluminium-zirconium alloys and in 1957 brought the production of pure silicon for transistors to the pilot plant stage.

CHEMICALS PRODUCTION

Although aluminium now accounts for nearly two-thirds of the company's sales, Pechiney was originally founded for the production of chemicals. Apart from its own production the company has holdings in a large number of subsidiaries, and the total output of chemical products

increased by 22 per cent. in 1956. The output of chlorine has risen from 12,000 metric tons in 1938 to 55,000 m. tons in 1956 and the capacity of the electrolytic plant at St. Auban is now 230 m. tons per day. The hydrogen produced is used for the manufacture of ammonia and at the beginning of 1957 a new ammonia plant was brought into commission in order to utilise the whole of the electrolytic hydrogen available. A new plant for the production of perchlorethylene was also brought into commission. Another product at St. Auban is polyvinyl chloride (P.V.C.) of which Pechiney are the largest producers on the European continent. They are also prominent in the production of other types of plastics and at the end of 1953 in conjunction with Houillieres du Bassin du Nord et du Pas-de-Calais and the S.A. Progil founded the Ste. Houilliere Pechiney-Progil for the production of styrene monomer at Mazingarbe. The plant has a yearly capacity of 10,000 to 14,000 tons and the styrene is used for the production of polystyrene at a plant at Ribecourt owned jointly by Pechiney and the Ste. des Produits Chimiques de Ribecourt. In 1954 the output of polystyrol was 1,800 tons. Another subsidiary of Pechiney, the Ste. Ethylene Plastique manufactures polyethylene at Mazingarbe. The company originally operated the high-pressure process under licence from Imperial Chemical Industries Limited, but in 1955 took up a licence for the German Ziegler low-pressure process.

Pechiney also have interests in the petroleum chemicals industry and a subsidiary, the S.A. Naphtachemie, operate a plant with a capacity of 8,000 tons of ethylene oxide per annum. A second plant is expected to be completed this year. Pechiney is also one of ten companies which founded the Ste. de Caoutchouc Butyl in Rouen for the manufacture of synthetic rubber. The planned yearly capacity is 20,000 tons which it is estimated will result in a saving of about 5 million dollars per annum in foreign currency.

The above examples by no means cover all the ramifications of Pechiney in the chemical industry: the company's chemical output ranges from sulphuric acid, caustic soda, chlorates, calcium carbide and nuclear graphite to insecticides and a synthetic fibre, Rilsan, produced from castor oil which is derived from plantations in French Africa owned by a subsidiary, the S.A. Organico.

The structure of the company is complex, since apart from plants owned by the company and its subsidiaries, Pechiney is strongly represented in co-operative enterprises together with other leading companies in the French metallurgical and chemical industries. It is also the policy of the company to assist regional development in France, which it does by participating in local companies and joining research groups particularly in the South Western and South Eastern regions. Investments in subsidiary and affiliated companies are made through a holding company, Ste. d'Exploitations et d'Interêts Chimiques et Métallurgiques (SEICHIME). The total capital invested by this company in mid-1956 amounted to Fr. 926 million against Fr. 359 million in 1955. Of the 1956 total 48 per cent. was invested in metallurgical enterprises, 45 per cent. in chemicals and 7 per cent. in mining and other undertakings.

COMPETITIVE STRENGTH

In both the metallurgical and the chemical fields Pechiney use predominantly raw materials of French origin; if, therefore, they can expand exports they are in a position to make an important contribution to the French balance of payments. At an extraordinary general meeting held in February, 1957, however, the directors pointed out that in spite of the marked expansion of output in the last few years the company had only been able to meet the growing demands of the home market by reducing exports. For this reason they were proposing to increase the rate of expansion of output and had decided to raise the capital of the company from Fr. 17,325 million to Fr. 25,987·5 million. Until further additions to capacity are completed the company is not likely to be in a position to expand exports, unless the French Government is forced to take steps to reduce domestic demand.

Under these conditions it is not easy to assess the true competitive strength of French industry. Average hourly earnings in French industry are low compared with the United Kingdom and the Scandinavian countries but higher than in Germany. On the other hand, obligatory social charges are relatively higher than in any other European country with the exception of Italy. At the beginning of 1956 they averaged just under 30 per cent. of earnings compared with 2·7 per cent. in the United Kingdom, 11·7 per cent. in Germany and 53·5 per cent. in Italy. Taking these into account total labour costs in France are slightly higher than in the United Kingdom and are the highest of all countries forming the European Common Market, though they are lower than those of Switzerland and the Scandinavian countries. In practice the burden of social charges on individual companies is often heavier than the official average figure, and in the case of Pechiney such charges in 1957 totalled Fr. 3,700 million, representing 57 per cent. of salaries and wages including bonus payments.

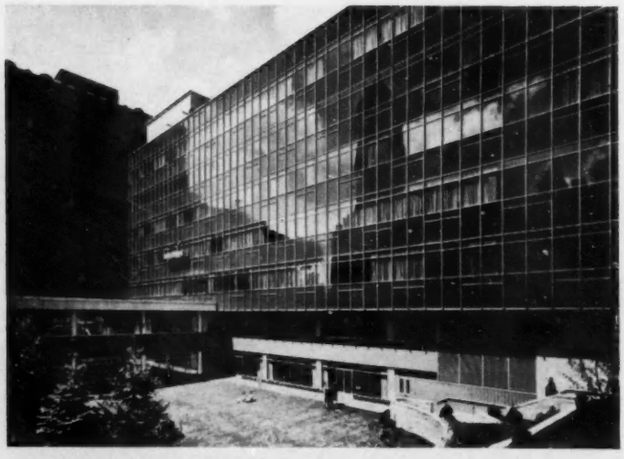
During the last three years French industrial production has increased rapidly; the index of industrial production compared with 1952 showed a rise of 11 per cent. in 1954, 23 per cent. in 1955, 32 per cent. in 1956 and 45 per cent. by the middle of 1957. Exports, however, declined by 6 per cent. between 1955 and 1956, but rose by 13 per cent. in the first four months of 1957. Imports on the other hand, rose by 21 per cent. in 1956 and 36 per cent. in the first four months of 1957. Imports of fuel and raw materials alone accounted for Fr. 800,000 million out of total imports of Fr. 1,500,000 million in 1956, and for Fr. 340,000 million out of Fr. 625,000 million in the early part of 1957.

The Minister of Industry in the last Government pointed out that for every 10 per cent. increase in industrial production it was necessary to increase imports by from 20 per cent. to 30 per cent. The possibility of rectifying the adverse balance of payments by limitation of imports is therefore strictly limited and relief can only be achieved by a marked expansion of exports or by the development of raw materials inside Metropolitan France or the French overseas possessions. In the long term a considerable improvement is likely to result from the development of raw material resources in North Africa and from the growth of atomic energy. It is unlikely, however, that these two developments can materially affect the position within the next eighteen months. If, therefore, France is to fulfil her obligations regarding the liberalisation of trade by the date set for the coming into force of the Common Market, a combination of measures will be required designed to reduce home consumption of non-essential imports and to stimulate exports. Companies such as Pechiney, which already make important direct and indirect contributions to the export trade and which are substantially independent of imported raw materials, are likely to receive every encouragement to further expansion.

ARCHITECTURAL APPLICATIONS OF VITREOUS ENAMEL

Vitreous enamel may be defined simply as glass fused to metal, but in point of fact the term is given to an entire class of inorganic coatings applied to metal surfaces to form a relatively thin but continuous protective covering. When giving this definition in a recent lecture in London, organised by the Vitreous Enamel Development Council, 11 Ironmonger-lane, London, E.C.2, Mr. B. Zick, of Ferro Enamels, Limited, Wolverhampton, added that modern vitreous enamels covered a very wide range of composition making possible the application to metals ranging from aluminium, copper, iron and steel, to stainless steel and high-nickel alloys. Great variation was likewise possible in the physical, chemical, thermal and optical properties of these materials. The manufacture of enamel was normally a two-stage operation. First the basic glass, or " pit," as it was termed in the trade, was milled together with clay, water and other ingredients, to make a " slip " or slurry, which was then applied to the metal by dipping or spraying; after this the coating was dried and fired. A vitreous enamel was essentially a high-temperature material for, during processing, it was fired at a temperature varying from 560 deg. C., on aluminium, to the range 700 deg. to 900 deg. C., on iron and steel, and 960 deg. C., and upwards, on stainless steels and nickel-chromium alloys.

Resistance to corrosion by acids and alkalis, to water and the weather, to heat and thermal shock, and to scratching, and surface textures ranging from full gloss to full matt, and an infinite variation in colour, were all readily available in any desired combination. Articles in glass fused to metal ranged from jewellery enamel to the combustion chamber of a gas turbine, where a material was applied to a nickel-chromium alloy and was called a ceramic coating. The principal qualities which made vitreous-enamelled components of interest to the building industry were that the surface was impervious to vapour and moisture, chemically resistant, easy to clean and permanent in colour, and that durable, bright hygienic interiors with negligible maintenance costs might be a logical corrollary to exteriors possessing the same qualities.



Facade of Lutheran Building, Minneapolis, Minnesota, U.S.A., showing the vitreous-enamel panel and glass-window construction.

The architectural applications of vitreous enamels, or porcelain enamels as they are called in America, were further dealt with in a second lecture by Mr. Edward Mackasek, consultant to the Porcelain Enamel Institute of the United States, who dealt with the development of these materials in the building field in America. He stated that since the acceptance by the architect of the vitreous-enamelled metal-clad

wall, or "curtain wall" as it was referred to at present, a new type of architecture had evolved. By using a curtain wall which might weigh only from 5 to 10 lb. per sq. ft., compared with a masonry exterior wall weighing from 90 to 100 lb. per sq. ft., a considerable reduction on the load on the structural elements and footings was obtained, with consequent savings in cost. The erection of the exterior walls proceeded far more rapidly with curtain walls than with masonry construction. Thus, a group of 40 workmen, commencing at 6 a.m., had completely enclosed a 22-storey office building in New York City in 9½ hours. A masonry wall would have required months. The new method of building was being used for constructing hotels, office buildings, schools, restaurants, garages and filling stations and other structures.

An example of architectural enamelling is furnished by the new Lutheran Building in Minneapolis, Minnesota, shown in the accompanying illustration. In the lower right-hand corner are seen the aluminium air-conditioning louvres while, on the left, in line with what appears to be the third storey, is a cradle suspended from the roof. This is electrically driven and enables maintenance men to wash the windows and enamelled steel panels of the building.

NON-DESTRUCTIVE TESTING

Visual X-ray Image

An apparatus for the non-destructive examination of large quantites of components has recently been designed by Marconi Instruments, Limited, St. Albans. The equipment, a 250 kV constant-potential fluoroscopic and radiographic unit, produces an X-ray image that can be examined visually. The Nobel Division of Imperial Chemical Industries, Limited, have installed one such unit and use it to check fuses, fuse wire, detonators, and other components. Apart from the facility of fluoroscopy (direct visual inspection) the equipment can be used for radiography.

The tubehead with its associated components is housed in a lead-lined case. The high-tension generator, the oil cooler, and the control unit are all of standard design. Operation of a pedal opens a shutter in the front of the case, permitting the insertion of small components on a tray. Radiography of larger objects, up to 6 in. in diameter and 24 in. long, can be carried out by inserting the items through a door in the back. For radiographic inspection, the operator inserts a film casette above the tray.

The seated operator, looking through a viewing hood positioned above the shutter, sees the fluoroscopic image reflected on a first-surface mirror. In this way, and by the use of layers of lead glass, the operator is shielded from direct radiation. Further protection is provided by means of the ¼ in. thick lead-lined case, and an interlock system that prevents generation of X-rays when either the shutter or the back door is open.

Small components can be checked rapidly with the fluoroscopic and radiographic unit. A mirror and lead glass screens shield the operator from direct radiation.

RESEARCH ON CAST IRON

The highlight of the open days, held on July 3 and 4 by the British Cast Iron Research Association at their headquarters, Bordesley Hall, Alvechurch, Birmingham, was the official opening, by the President of the Association, Mr. J. J. Sheehan, of a new melting shop. The shop, which is shown in the accompanying illustration, has a floor area of 75 ft. by 40 ft. and adjoining it, on one side, is a roomy extension and along the other side a motor-generator room, a pump room, an office and a sand store. The equipment installed includes two oil-fired tilting crucible furnaces of 250 lb. capacity, an oil-fired lift-out 80 lb. crucible furnace, and electric high-frequency melting equipment. A motor alternator of 200 kW output supplies four induction furnaces of 10, 5, 2 and 1 cwt. capacities. Also available in the new shop are gas-fired ladle heaters and a mould dryer, a jolt-squeeze roll-over moulding machine operated by compressed air and a sand mill of 3 cub. ft. capacity. The shop is served by a 5 ton electric overhead travelling crane. Facilities for cupola melting, including the use of hot-blast equipment, is to be installed at a later date.

Other newly-acquired equipment includes a battery of six 5 ton creep-testing machines. These will enable creep tests to be carried out on cast irons selected on the basis of accurate growth tests conducted at various temperatures up to 600 deg. C.

Research is carried on at Alvechurch on such subjects as the soundness of iron castings, the characteristics of white cast irons, the mechanical properties of all grades of cast iron, the testing of foundry sands, gases in cast iron, the properties of malleable cast iron, the corrosion, of irons, the dephosphorisation of foundry irons, and foundry atmospheres. This last-mentioned branch of the Association's activities was formed in 1951 and its work comprises an advisory service and experimental investigations on dust flow and dust control. Proposals are under consideration to provide a new laboratory block to give adequate experimental facilities for the foundry atmospheres section. Field investigations of dust collectors used by foundries will be made, and data collected for statistical analyses to evaluate the behaviour of various types of equipment in different applications. The results should help to solve the "clean-air" problem and assist in providing specifications necessary for foundry dust control. So far, over 70 reports have been issued.

New melting shop at the Alvechurch head-quarters of the British Cast Iron Research Association. The shop is served by a 5 ton electric overhead travelling crane, and the equipment includes two 250 lb. oil-fired tilting crucible furnaces, an 80 lb. oil-fired lift-out crucible furnace, and 10, 5, 2 and 1 cwt. electric high-frequency induction melting equipment.

TITANIUM IN CHEMICAL AND ALLIED PLANT

The purpose of an exhibition, held recently in London, by Imperial Chemical Industries, Limited, was to remind the visitors of the noteworthy characteristics of titanium, namely, its high strength to weight ratio, good mechanical properties even at elevated temperatures, high resistance to erosion, and outstanding resistance to most forms of chemical attack and to stress-corrosion cracking even in hot chemical liquors. These properties indicate that the metal is particularly suitable for the construction of many forms of plant employed in the chemical, petroleum, textile and pulp-making industries. Some examples of such uses of titanium were on view, including high-pressure needle valves, pump impellers, trunking, gas nozzles, and tubing. Samples of titanium wire mesh, expanded-metal mesh, and perforated filter plate were also on view. The use of titanium in the form of a thin lining inside a steel vessel is of considerable interest, the lining providing the corrosion resistance and the steel shell the necessary strength. Inquiries regarding potential applications of titanium should be addressed to Imperial Chemical Industries, Limited, Metals Division, P.O. Box 216, Birmingham, 6.

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SEALING MACHINE FOR POLYTHENE BAGS

A single-action electrically-operated machine for the rapid heat sealing of bags and tubes of Polythene and other materials of similar type has been placed on the market by the Hypak Division of the Oppenheimer Casing Co. (U.K.), Limited, 159–165 Harrow-road, Paddington, London, W.2. The machine, called the Hypak Polysealer consists essentially of a base and sheet metal cover enclosing a 13 in. horizontal sealing blade upon which are mounted heating elements. The blade is secured to two pivoted arms and, in operation, is depressed by hand on to a sealing bed. Designed primarily for the sealing of bags containing merchandise of various kinds, including liquids, powders or other free-flowing materials, the two ends of the open neck of the bag are held flat on the sealing bed and the operating control plate of the machine depressed by the knuckles of the operator. The action is instantaneous and the hair-line coalesced seal produced is air-tight.

The machine is available for bench or wall mounting: it measures 17 in. by 9¾ in. by 8½ in., and its gross weight is 13 lb.

CIRCULATION IN HIGH-PRESSURE BOILERS

INDUSTRY AND UNIVERSITY CO-OPERATE ON RESEARCH PROJECT

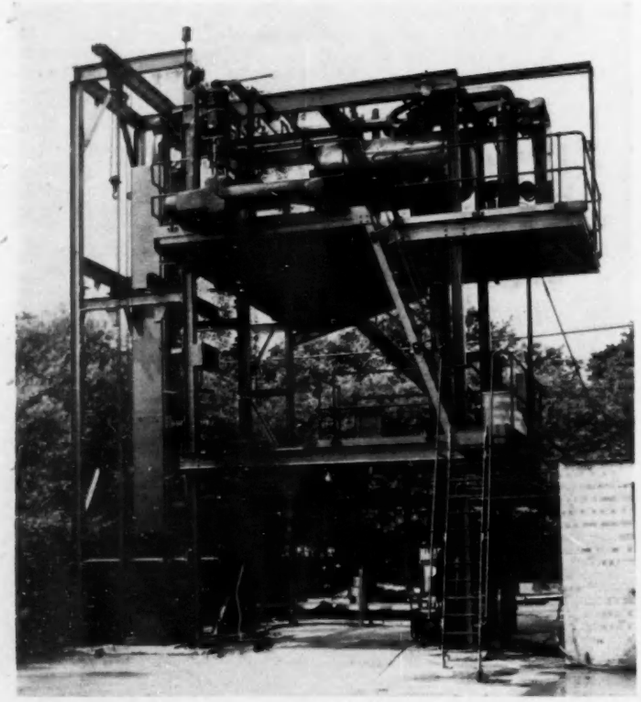


Fig. 1 Plant for the study of boiler circulation theory, showing test section (left) in the vertical position; it can also be arranged horizontally. The research projected is operated by the Engineering Department of Cambridge University and sponsored by the Water-Tube Boilermakers' Association.

Boiling water is still, after several centuries, and in spite of recent innovations, among the most satisfactory methods of producing power. Even the advent of nuclear energy has not displaced the boiler, for water is the working fluid in numerous reactors, from the systems in which it serves directly as the reactor coolant to those in which it is heated in a heat exchanger by a primary liquid or gas. But although the principle has not changed, the demands made on steam plant have vastly increased. Since the war there has been a trend towards higher pressure-temperature cycles, and a modern water-tube boiler may be expected to operate at a pressure as high as 2,800 lb. per sq. in. With this in mind, the Water-Tube Boilermakers' Association decided to sponsor a research project undertaken earlier by the Department of Engineering in the University of Cambridge. The project is concerned with the fundamentals of circulation theory in high-pressure boilers and other forms of evaporative heat exchanger, and its main object is to establish experimental data relating to the pressure drop and flow conditions in a steam-water mixture flowing along heated and unheated pipes at pressures up to the critical, that is, 3,206 lb. per sq. in.

Little information on the subject is available, but it is a field of growing importance, particularly in the design of high-pressure boilers for power stations and of heat exchangers for nuclear plant. The results may also be applicable to the design of water-tube boilers for marine use. The project provides an example of close co-operation between a university department and a commercial trade association. The present article discusses the background to the project, its organisation, the nature of the experimental plant employed, and the progress already made.

Historical Context

In 1950 the attention of the Water-Tube Boilermakers' Association was drawn to certain experimental work being undertaken by the department of engineering in the University of Cambridge. This work, started the previous year, was confined to a simple U-circuit at atmospheric pressure, without steam production in the riser, and was related to some theoretical studies which were being made on the rate of circulation in a simple boiler circuit. These studies resulted in a unification of the existing, but previously conflicting, theories on the subject known as the "hydraulic," "thermodynamic" and "expansion" theories of circulation.

This theoretical analysis was published in a paper entitled "Research into the Fundamentals of Boiler Circulation Theory," by Mr. R. W. Haywood, presented to a general discussion on heat transfer, organised jointly by the Institution of Mechanical Engineers and the American Society of Mechanical Engineers, and held in London in September, 1951. The paper was deliberately confined to a study of circulation theories which were based on the assumption that the steam-water mixture moved as a homo-

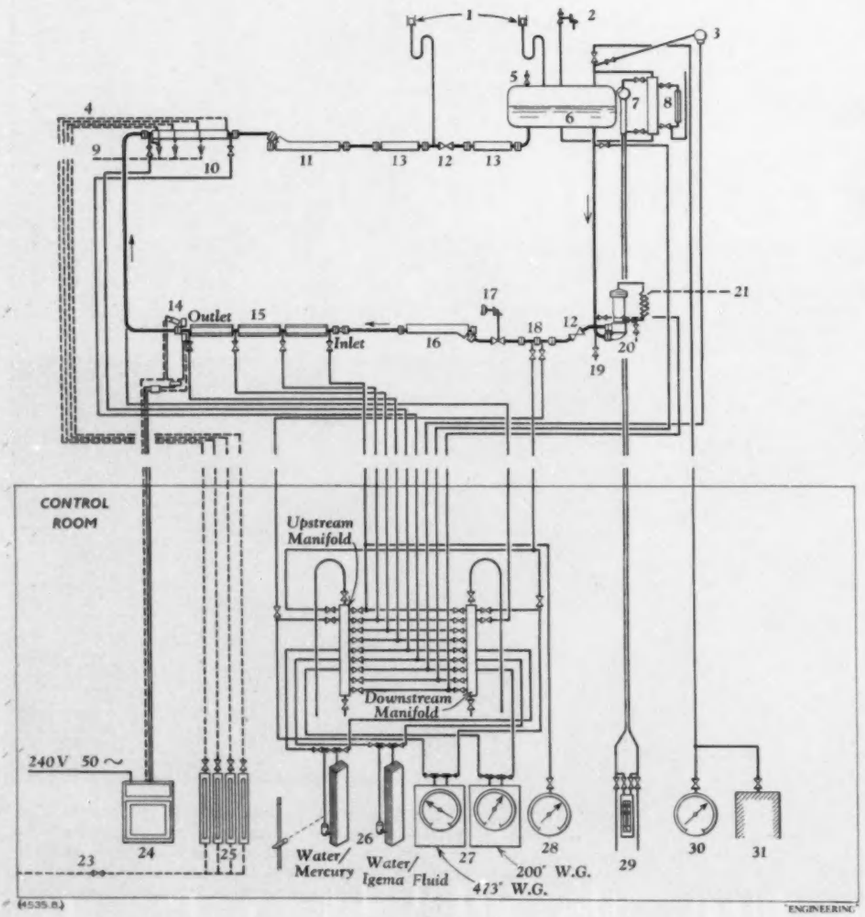


Fig. 2 High-pressure test circuit for study of boiler circulation theory.

1. Rupture discs
2. Emergency blow-off and air vent operated from control room
3. Constant head chamber
4. Condenser cooling water (via flowmeters in control room)
5. Filling connection
6. Steam and water drum
7. Constant head chamber and water bottle for remote liquid level indicator
8. Gauge glass (low pressure) for filling only
9. Discharge to drain
10. Calorimeter concenser
11. Re-heater (hand controlled)
12. Emergency valve (automatic closure)
13. Drum heater (hand/automatic control)
14. Gamma-ray device
15. Electric induction heaters surrounding test section
16. Pre-heater (hand controlled)
17. Flow-control valve (operated from control room)
18. Metering orifice
19. Blowdown valve
20. Immersed pump : 60 ft. head: 53 g.p.m.
21. Cooling water (town supply)
22. Head amplifier
23. Cooling water (town main)
24. Vibrating reed electrometer and recording unit
25. Flowmeters (cooling water)
26. Differential pressure manometers
27. Differential pressure gauges
28. Pressure gauge (inlet to test section)
29. Remote liquid level indicator
30. Pressure gauge (drum)
31. Automatic pressure control

geneous fluid, because the existing theories took this assumption as their starting point. It was the purpose of the paper to show how these differences could be resolved. The assumption is known to be questionable, but its use is usually justified by the resulting simplification in a theoretical approach to the problem of circulation. In the conclusions to the paper attention was drawn to the limitations of the experimental work undertaken at Cambridge, in that, in the absence of steam production, it was not possible to study the effect of relative velocity between the steam and water phases of a steam-water mixture. This phenomenon, commonly called bubble slip, is known to exist under actual flow conditions in a boiler circuit. It was consequently indicated that there was a need to establish experimentally further data relating to pressure drop, and to the conditions of steam production, at the pressures employed in industrial plant.

Following a report from technical representatives of member companies of the Association, who visited the Engineering Laboratories at Cambridge to study the work, and after consultation with Professor J. F. Baker, the head of the department of engineering, the Association agreed to sponsor an experimental research project proposed by the University as an extension to the existing work. A research contract was accordingly signed with the University in 1951. Most of the available data on this subject had been obtained at pressures of less than 100 lb. per sq. in., but the Association-sponsored project, essentially fundamental in conception, is expected to provide much needed data over a wide range of pressures.

Planning and Organisation

Under the terms of the research contract it was agreed that the Association should provide the high-pressure drum and pipework, together with their structural supports, and this equipment was supplied, delivered and erected by one of the member companies. A technical advisory panel, comprising representatives of the department of engineering and of the member companies of the Association, was formed to advise on practical and technical problems arising during the development stages, and to plan the scope of the proposed test programme. The project, however, falls under the general supervision of Professor W. R. Hawthorne, Professor of Applied Thermodynamics, and is directed by Mr. R. W. Haywood, a university lecturer in the department with considerable industrial experience in both the design and testing of steam power plants.

Early in 1952 the University acquired the site of a disused aircraft factory on the outskirts of Cambridge. This has been used as a research out-station, and a portion of the site was allocated to the present research. The main advantage offered by this site over an alternative one in the laboratories of the department itself was that the safety factor was greatly increased by erecting the test circuit in the open air, as can be seen in Fig. 1. The site also offered additional advantages in that increased electrical power supplies at standard voltage were readily available from an adjacent substation and the plant could be operated by remote control from a brick-built control room. There were, of course, certain disadvantages, particularly during the winter when climatic conditions would make external working unpleasant. Severe frosts could also cause trouble, but this was obviated by fitting small electrical heating leads to all static water pipes, and the effects of rain on the electrical insulation were minimised as far as possible by extra protection.

Erection of the pressure parts and supporting structure began during 1953. Several delays were experienced, primarily on account of the nature of some of the problems which had to be solved—particularly in the design, development and construction in the engineering laboratories of the induction heaters, differential thermocouples and differential pressure manometers for use at elevated pressures. There were also delays due to late delivery of essential equipment.

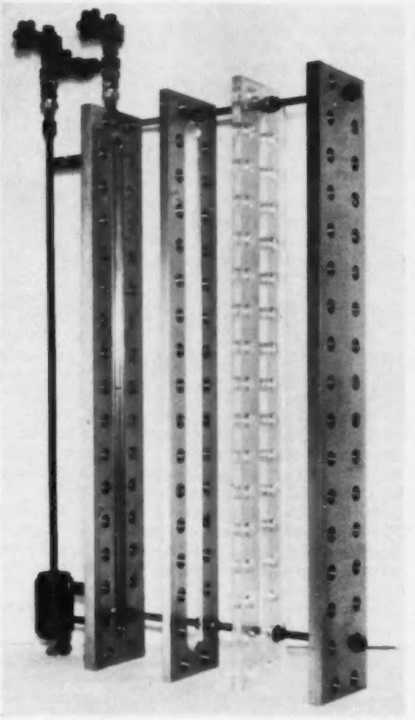


Fig. 3 Differential high-pressure manometer. The test plant is designed to provide data on pressure drop and flow conditions in a steam-water mixture flowing along heated and unheated pipes at pressures up to the critical (3,206 lb. per sq. in.).

Fig. 4 To measure the apparent density of the steam-water mixture leaving the test section and hence the relative velocities or slip between the two phases a gamma-ray device is used.

Objectives and Equipment

The primary objective is the establishment of experimental data relating to the pressure drop and flow conditions of a steam-water mixture flowing along heated and unheated pipes at pressures up to the critical pressure of steam. Studies are being made of the effect of several variables, including pressure, heat-input rate, internal diameter and inclination of test-section, the velocity of the water entering the heated test-section, and the dryness fraction of the emergent steam-water mixture.

The test-section is 24 ft. in length, but the heaters have been designed to permit heating over 8, 16 or 24 ft. as desired. By this means the pressure drop in the unheated pipe following the heated part of the test-section can be measured at selected inclinations. To afford control over all the variables, assisted circulation has been adopted, so that the velocity of the entering water is independent of heat input. This also permits direct determination of the friction coefficient when circulating hot water alone at any pressure and rate of flow, prior to tests under conditions of steam generation.

Test Circuit

The high-pressure test circuit is shown diagrammatically in Fig. 2. Water in the saturated condition from a steam drum flows through an Electromersible high-pressure circulating pump in a continuously re-circulating closed system. The rate of circulation is measured by a standard orifice assembly, and is regulated and maintained constant by adjustment of a control valve. An electrical pyrobar immersion-type pre-heater is used to ensure that the fluid enters the inlet of the heated test-section at exactly the saturation temperature corresponding to its pressure at that point, thus offsetting heat losses in the pump and connecting pipework and the effect of pressure difference between the test-section inlet and the steam drum. Accuracy is achieved by measuring carefully the differential pressure between the test-section inlet and the drum, and then adjusting the differential temperature—which is measured directly by accurately calibrated thermocouples of high sensitivity—to correspond to this pressure difference. Consequently, steam generation commences exactly at the inlet and takes place along the entire heated length of the test-section. When desired, only the first 8 or 16 ft. of the test-section need be heated, so that both evaporating and non-evaporating conditions can be investigated.

The differential pressure between the test-section inlet and the drum and the pressure drops resulting from the flow of the fluid between various parts of the experimental plant are measured either by a direct-reading mercury or by an image manometer, both of which were designed and manufactured in the engineering laboratory. These meters replaced, for accurate work, the commercial differential pressure meters which were fitted at the outset, and which for various reasons have never given satisfactory service. A high-pressure manometer is shown in Fig. 3.

To the test-section outlet is connected a short one-foot length of alloy-steel tube, the contents of which are scanned by a gamma-ray beam from a small capsule containing a radioactive isotope of caesium. The use of the high-tensile steel alloy enables more sensitive readings to be obtained from the gamma-ray device by reducing the wall thickness of the pipe and thereby its screening effect. An ionisation chamber at the opposite end of the diametral axis acts as a receiver, and measures the emergent radiation which is a function of the density of the contents of the pipe. This equipment, which is shown in position in Fig. 3 and has been supplied on loan by the Atomic Energy Research Establishment, Harwell, enables an estimate to be made of the apparent density of the fluid mixture leaving the test-section, and consequently the respective velocities of the two phases at that point. As has been noted, the relative velocity of the two phases is known as bubble slip. It should be noted that the velocities thus calculated are "average" values, and provide means of estimating the pressure drops due to acceleration and wall friction. A knowledge of the mean density is also particularly valuable when the test section is in the vertical position.

Originally the source consisted of a 1 by 1 mm. capsule of iridium 192 having a strength, when new, of about 40 millicuries, and a half-life of only 70 days. The present source is a 2 by 2 mm. unit of caesium 137 of similar strength, but with a half-life of 33 years. The source emits radiations in every direction, and when the test-section is in the horizontal position those radiations travelling downwards pass through the pipe and its contents. The emergent radiation, which is a

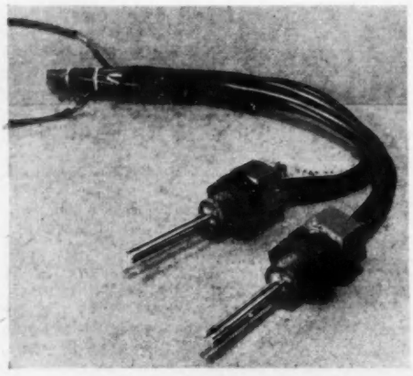


Fig. 5 Differential triple-point thermocouples are used to measure the temperature rise of the cooling water in the induction heating units.

function of the density of the contents of the pipe, is measured in the ionisation chamber at the opposite end of the diametral axis. The current flowing through the chamber is related to the amount of radiation received, and this current is fed to an electrometer designed for measuring direct currents in the range 10^{-8} to 10^{-15} amps. It has been agreed that two more of these devices should be mounted on the vertical test section at the 8 and 16 ft. levels. In this way it will be possible for build-up of slip, which is expected to be more marked in the vertical position, to be fully studied.

For convenience and safety it is desirable to use a weak source, and the sensitive ionisation chamber and high-magnification electrometer enables this to be done. However, to improve even further the sensitivity of the device, a secondary or "backing-off" ionisation chamber is fitted as shown in Fig. 4. The use of this chamber indirectly enables the very small changes in the ionising current resulting from changes in the density of the fluid to be magnified and more easily measured.

On leaving the test-section the steam-water mixture enters a water-jacketed condenser and finally passes through an electrically-heated re-heater before returning to the drum. Constancy of the operating pressure is maintained by combined adjustment of the quantity of condenser cooling water and the electrical input to the re-heater.

Complete automatic control of the circuit is not intended, and the initial tests have been regulated entirely by manual adjustment. Thermocouples are installed at various parts of the circuit. These will, if required, supply direct readings of temperature in the usual manner, but where temperature differences are more important the individual couples are connected in opposing pairs to give differential readings, thus saving time and also reducing the observational error in the readings. Thermocouples are also "peened" into the outer surface of the test-section tube wall in order to keep a check on tube over-heating.

It may be interesting to consider the use of thermocouples in the plant in further detail. A most important requirement is to measure accurately the difference between the temperature of the water at the test-section inlet and that in the drum, in order to ensure that the water enters the test-section at a temperature as close as possible to its saturation temperature. The approach chosen was to measure this difference directly by two thermocouples connected differentially, so that the wires of each thermocouple have to be electrically insulated from the sheath in which they are carried. This arrangement introduced difficulties which had to be solved before a design capable of withstanding the pressure, yet of sufficient accuracy and sensitivity, could be obtained. In the final design the couples are of chromel-constantan wires, since they give a high e.m.f. for any specified level of temperature, the wires being continuous from hot-junction to cold-junction.

Before the final design was evolved, and in order to obtain rapidity of response to temperature changes, a number of alternative constructions were investigated. In the design adopted the couple wires are not welded to the tip of the sheath, and high sensitivity is obtained by making the extremity of the sheath of thin-walled stainless-steel tubing. It is consequently believed that, as a result of this development, the temperature difference recorded by these couples will be reliable to approximately 0·5 deg. F. over the range of temperature levels encountered.

A further development is the use of triple-junction differential thermocouples to measure the temperature rise of the cooling water flowing through the coils of the induction heating units. Examples of triple-point thermocouples are illustrated in Fig. 5. The cooling water, which is circulated to maintain the copper tubing at a safe temperature level, carries away the major heat loss from the heaters, and its rise in temperature must therefore be accurately measured if the useful heat input over the heated length of the test section is to be known with certainty. This temperature rise is less than 10 deg. F., and the accuracy of measurement of the difference is greatly increased by the adoption of the triple-junction differential thermocouples.

Heating System

Various alternative methods of heating the test-section electrically were considered, the main requirements being ease of control and uniform heat input per unit length of pipe. Low-frequency induction heating was finally adopted as it did not require electrically-insulated high-pressure joints and was adaptable to three-phase heating for increased heat inputs. It has proved admirably suited to the purpose. A close-up view of two completed units of the test section appears in Fig. 6; the test section is seen in the vertical position.

The high-grade steel used for the manufacture of the tubes is not ideal for high-intensity electrical loading, but by spraying the outside of the tubes with copper approximately 0·05 in. thick, an extra electrical conducting path is made available, which greatly increases the possible loading.

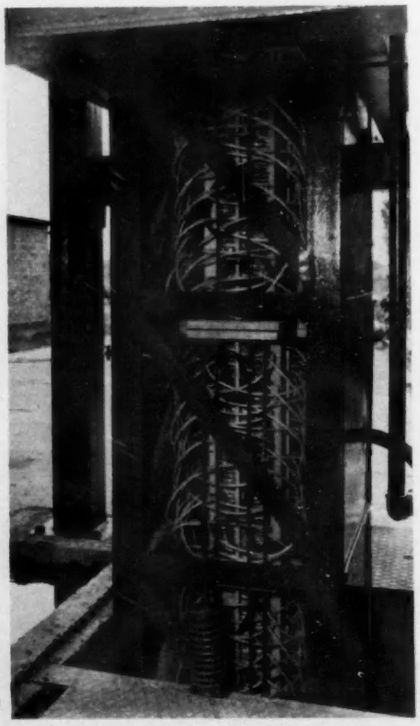


Fig. 6 The test section (shown here vertical) comprises six 4 ft. induction heating units, two of which can be seen.

There are mounted on the test-section six of these induction heating units, each of which is 4 ft. long. Each unit is divided into six sections, each of seventeen coils, the coils being made from lengths of high-conductivity copper tubing. The use of tubing allows for water cooling. The coils, each of which has $11\frac{1}{8}$ turns in any section, are connected electrically in series. The six sections can be connected in suitable series and parallel combinations to busbars provided along the length of the unit, as required for different power settings. It will be appreciated, therefore, that by suitable selection of units, the heating may be applied to the test-section in lengths which are multiples of 4 ft., although it has been the practice so far to use heating lengths which are multiples of 8 ft.

Very little information was available on this type of low-frequency induction heating and much preliminary work—itself in the nature of a fundamental investigation—had to be completed to establish what heat-input rates were possible. The results of this investigation are also expected to be of value in other applications. The design of heater finally adopted permits the power supplied to be varied over a considerable range in a number of steps without the use of an expensive voltage regulator; the heaters were made in the engineering department.

Progress

The various developments mentioned previously, together with the method evolved for determining the flow conditions from the readings taken with the gamma-ray equipment, have been the subject of short individual reports to members of the Association.

Preliminary trials were carried out with a test-section of 1 in. bore, 24 ft. long, mounted in the horizontal position. These were planned mainly to enable the operating staff to become familiar with the response of the respective controls, and to check the accuracy of the various measuring and recording instruments. A further series was subsequently conducted at four pressure levels, and the results carefully analysed. Proposals were made for improving the operation of the experimental plant—by effecting certain refinements to the equipment and operating technique—and these were accepted by members of the technical advisory panel. It had been agreed earlier that the operating technique should be perfected with the test section in the horizontal position since the gravitational effects in a vertical pipe were expected to render the analysis more difficult.

The first full series of tests was then effected on the 1 in. bore horizontal test-section at five pressure levels, namely 250, 600, 1,250, 2,100 and 3,000 lb. per sq. in. The results of these tests, together with those obtained from other tube sizes at various inclinations, will be published in due course.

The direct costs of the project have amounted to approximately £45,000 up to December 31, 1956. These include cost of equipment and operating costs, and it seems likely that running costs will continue at approximately £8,000 annually. Further information on the project, which has been described as "a unique marriage between the scientific and practical approaches," may be obtained from the Water-Tube Boilermakers' Association, 8 Waterloo-place, London, S.W.1.

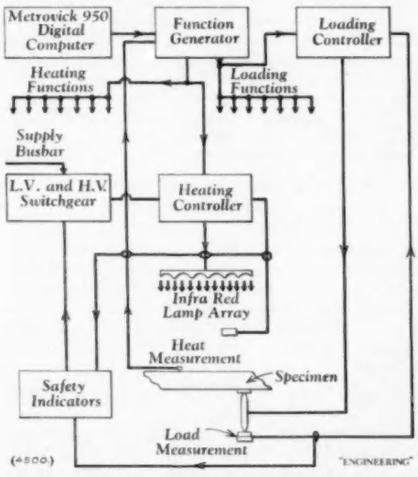
The members of the W.T.B.A. are Babcock and Wilcox Limited; Clarke Chapman and Company, Limited; International Combustion Limited; Simon-Carves Limited; John Thompson Water-Tube Boilers Limited; and Yarrow and Company, Limited; while associate members are Aiton and Company, Limited; Stewarts and Lloyds Limited; and the Superheater Company, Limited.

SIMULATING KINETIC HEATING IN HIGH-SPEED AIRCRAFT

To reproduce in the laboratory the conditions likely to be met during high-speed flight, in order to study the deformations caused by thermal stress where unequal temperature distributions arise from changes in speed, a complete simulation system has been developed by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, and is now available to aircraft manufacturers.

The power requirement for the simulation of kinetic heating varies with the size and designed operating conditions of the specimen under test, from tens of kilowatts in pilot schemes to tens of megawatts where a full-sized project is on test. In the Metrovick system, provision has been made to supply either controlled alternating current or controlled direct current to meet this need; controlled direct current systems are generally favoured because of interference problems on the large numbers of measuring instruments. The power controllers may be either static (flux-resetting magnetic amplifiers or mercury-arc rectifiers) or dynamic (field-controlled direct-current generators or servo-controlled alternating-current regulators), all being available in types having the required response.

A block schematic of the whole simulation system is given in the accompanying illustration.



Block schematic diagram of the heating simulation system.

It will be seen that the control system for heating and stressing comprises a Metrovick 950 digital computer, a function generator, and loading and heating controllers. The computer is used to produce the parameter programme on which the tests are to be conducted. Its output can be on five-hole punched paper tape, which is then fed into the function generator.

The simplified equation for heat flow into the structure gives:

$$\frac{Q}{A} = h\,(T_{aw} - t_s)$$

where $\frac{Q}{A}$ = computed heat per unit area (required),
h = heat transfer coefficient.
T_{aw} = adiabatic wall temperature,
and t_s = specimen surface temperature.

The function generator has been designed with a view to the addition of further terms in cases where a more rigorous solution is required. It has also been arranged to provide, where required, a programmed control of forces applied to the structure during the test in synchronism with the heating cycle. The heating and loading programmes can be produced either by a single function generator, or where the time scales differ, by separate function generators. Systems can also be arranged to control the surface temperature t_s instead of the heat flow Q if so desired.

The outputs of the function generator are taken to the several heating and loading controllers, but for simplicity only one heating controller and one loading controller are shown in the block diagram. The output of the heating controller is taken to a bank of infra-red lamps, which are suitably located with respect to the structure specimen. The heat measurement devices feed back signals to the function generator and heat controller to maintain the desired heating function. Similarly, the output of the loading controller is taken to the load actuator and load-measuring device, which applies the required force to the structure and provides a signal that is fed back to the load controller.

For protection in the event of structural or system failure, circuits are included which can be arranged to shut down the heating and loading systems with minimum delay. High-voltage and low-voltage switchgear can also be supplied to suit the user's requirements.

The objective of this new Metropolitan-Vickers development has been to provide a co-ordinated system for kinetic heating tests, while retaining the flexibility necessary to meet the varying requirements of different users. All the equipment from the h.v. switchgear and transformers to the infra-red lamps with their reflectors and supporting structures can be supplied by the company, thus relieving the user's staff of the work of designing their own gear or co-ordinating the specifications of individual items obtained from different suppliers.

THE FULMER RESEARCH INSTITUTE

The tenth anniversay of the official opening of the Fulmer Research Institute by Sir Stafford Cripps, on July 2, 1947, has been celebrated as an open day, and some conception of the growth of the Institute during the ten years of its existence is afforded by the fact that its annual research income has risen steadily from £25,000 in 1947, when the staff numbered 44, to £125,000 in 1957, with a staff of 107 persons.

The Institute is a sponsored research laboratory, the aim of which is to provide a scientific and technical service for the industrial community. Investigations are conducted on a strictly confidential basis and the results, including patents, belong entirely to the individual sponsor. Thus, the Institute—literally a laboratory for hire—can be viewed as a simple extension of the private facilities of a company. It is interesting to note, however, that about half the Institute's work is for Government departments and nationally-owned undertakings. It is pointed out, moreover, that recently there has been a marked increase of sponsorship from the United States, both from the Government and from industry, and the present annual value of dollar contracts exceeds 120,000 dols.

Most of the work of the Institute is of a metallurgical or chemical character, but problems relating to glass, ceramics, plastics, textiles, timber and asbestos, which have come within the orbit of the training and experience of the staff have been successfully undertaken.

Of the research and development work now in progress, special attention may be drawn to that on oxidation-resistant alloys. Low-alloy silicon-aluminium steels have been developed which, in air in the temperature range 600 deg. to 950 deg. C., exhibit oxidation rates claimed to be comparable with those of 18 : 8 stainless steel. These steels are expected to find application in heat exchangers, electric furnaces and elsewhere. The present shortage of strategic alloying additions such as nickel, is an added advantage of this class of steels, and development work is being continued.

A study of the mechanism of precipitation hardening, with particular reference to light alloys, has always been a major item in the Institute's research programme. Trace elements have been shown to exercise a profound effect on ageing behaviour in some systems, and the influence of small quantities of cadmium in accelerating the ageing of aluminium-copper alloys has resulted in the development of the aluminium-copper-cadmium alloys, which, while free from room-temperature ageing after solution treatment, can be aged at elevated temperatures to give properties approaching those of the Duralumin-type alloys. The new alloys, moreover are fabricated, hot or cold, more easily than the Duralumin-type and can be machined accurately without any movement, due to the occurrence of relief stresses. They are also claimed to show improved stress-corrosion properties compared with the Duralumin-type alloys.

Other metallurgical work includes the development of an aluminium-tin bearing alloy and of a structural alloy having improved corrosion resistance, also the investigation of the light fastness of anodic finishes on aluminium alloys and of a method of protecting light-alloy forgings and extrusions. The development of the catalytic distillation method of aluminium production is continuing. A related process for the preparation of titanium has been carried out on laboratory-scale apparatus and the method is ready for extension to the pilot-plant stage.

MATERIALS HANDLING

Since nearly all materials have to be handled at some time in their existence, it is natural that the number of techniques for doing it is in proportion to the different types of materials that exist. It is equally natural that it should become a specialised subject, with as a corollary, its own official body. This is the Institute of Materials Handling, which was founded in 1953 and has its headquarters at 20-21 Tookscourt, Cursitor-street, London, E.C.4. The present membership of this body is well over 1,000 but as there must be far more engineers than this who are engaged on the regular handling of materials, the Institute is anxious for them to join their number.

To this end, a booklet has been issued, which gives background information regarding the Institute, together with its rules, aims and projects. On the title page it states that: "A major contribution is being made to industry by the rationalisation of materials handling processes. The Institute is founded on the necessity to ensure that the technique of handling keeps pace with the demands of productivity and distribution processes." There are six divisions of the Institute located in various industrial centres, comprising the Midland, North Eastern, North Western, Scottish, Southern and Yorkshire divisions. Within each division, local sections can be created according to need, and at present ten such have been formed and are functioning.

The booklet lists 14 main aims of the Institute, of which the first is "to encourage and promote the research and study of the techniques of materials handling," and the second is "to extend, increase and disseminate all knowledge of materials handling." Earlier in the booklet is a description of the function of the materials handling specialist.

PLASTIC YIELDING OF I-BEAMS

SHEAR LOADING EFFECTS ANALYSED

By A. P. Green and B. B. Hundy†*

Concluded from page 76, July 19

The first part of this article, published last week, reviewed various theoretical relations for correcting the simple theory of bending by taking into account shear force effects. In the second part, below, new experiments on plastic yielding are described and compared with experiments by other workers.

EXPERIMENTS ON MODEL I-BEAMS

A number of model experiments were carried out to test the theoretical estimates of limit loads and the suggestions for modes of deformation summarised in the previous section.

Two types of specimen, A and B, shown in Figs. 8 (*a*) and (*b*) were tested in such a way that yielding took place in the vicinity of the sections labelled XX. The specimens were bent in an Amsler universal testing machine under a three-point loading system as indicated in Fig. 8 (*c*). The load was applied directly to specimens A on the thicker part of the beam, which was designed to give maximum strong support at the section XX in the vicinity of which yielding occurred. Specimens B were uniform in cross-section and the load was simply transmitted through an intermediate block; this was done in an attempt to avoid local deformation under the point of loading, and at the same time localise the region of yielding just to the right of XX, the section coinciding with the end of the block.

Specimens of type A were made with two shapes of cross-section which differed only in the width of the flanges, and the nominal dimensions of these cross-sections are given in Fig. 8 (*d*). Specimens of type B were made in one shape only, with wide flanges. The mean dimensions of actual specimens were obtained from numerous measurements made with a hand micrometer over the part of each specimen where yielding subsequently took place. They differed little from the nominal dimensions. The specimens were machined from a solid 1 in. thick slab of mild steel produced by the basic Bessemer process. After machining they were annealed in cast iron borings for one hour at 920 deg. C. before furnace-cooling to room temperature.

The angular deflection was measured by means of a dial gauge, placed as shown in Fig. 8 (*c*) about 10 in. behind one of the supports. The rate of loading was kept constant and was low enough to allow accurate load/deflection curves to be obtained. In the experiments where the measurement of the yield load was the primary objective, loading was continued some way beyond initial yielding, until the angular deflection was about 2 deg. or 3 deg. When it was desired to examine the mode of initial deformation, however, the deflection was restricted to about 1 deg.

After testing, small tensile test pieces were cut from unstrained portions of the flanges and webs of some of the specimens, and were tested in tension on the Amsler machine at a similar rate of loading to that used in the main tests, in order to determine the lower yield stress, Y.

The deformed part of each I-beam was heated for 30 minutes at 250 deg. C. and was then etched in a mixture of 45 grams of copper chloride, 180 ml. hydrochloric acid and 100 ml. water to reveal the regions of plastic deformation. Subsequently, in order to obtain a photograph of a vertical section of the regions of deformation in the web and flanges, the flanges were removed on one side and about 0·10 in. to 0·15 in. of material was removed parallel to the plane of the web by grinding and polishing, followed by re-etching (Fig. 8 (*e*)).

Results.—The mean value of the yield stress Y obtained from the tensile tests on unstrained material was 15·4 tons per sq. in.; the maximum variation from this mean value was ± 0·3 tons per sq. in. Some typical shear-load/angular-deflection curves are shown in Figs. 9 and 10. These were approximately linear until plastic yielding commenced. During the initial stages of yielding the curves for specimens A were usually fairly sharply rounded whereas many of those for specimens B exhibited an upper yield-point followed by a drop in load, e.g. B6 and B9 in Fig. 10. In all cases, it will be seen that the flat or slowly-rising portion after initial yielding was produced backwards in a straight unbroken line to the tangent to the elastic part of the curve to obtain the load corresponding to the beginning of plastic deformation in a similar idealised plastic body with a perfectly sharp yield point. There was little scope for ambiguity in the loads thus obtained. Furthermore they corresponded to small deflections, of an elastic order of magnitude. The experimental values of F and M were calculated from these extrapolated yield loads and the known positions of the load and supports. The value of M_o was calculated for each beam, assuming Y = 15·4 tons per sq. in., and in Figs. 11 and 12, M/M_o is plotted against F/YA_w for the beams with wide and narrow flanges respectively. In the same figures, theoretical curves are plotted for the purpose of comparison, using the mean dimensions of the appropriate sets of experimental specimens.

Typical examples of the regions of deformation revealed by etching the sections cut parallel to the web are shown in Fig. 13. Figs. 13 (*a*) to (*f*) show specimens of type A; Fig. 13 (*g*) is a specimen of type B. A single uniform I-beam was subjected to simple four-point loading and is shown in Fig. 13 (*h*); the pairs of load points were so close together at each end that instead of undergoing pure bending over the central part, the two end parts between the load points sheared in a manner similar to the mode shown in Fig. 6 (*b*). The load result for this specimen is plotted as a triangle in Fig. 11.

COMPARISON OF THEORY AND EXPERIMENT

When comparing the theoretical and experimental curves in Figs. 11 and 12, it should be borne in mind that corresponding experimental and theoretical points lie on the same straight loading line through the origin (e.g., OY in Fig. 11), since in any particular experiment, this loading line and not the value of F is specified in advance.

In the range $0 < \frac{F}{YA_w} < \frac{1}{\sqrt{3}}$ the experimental points for strongly-supported specimens A are scattered fairly evenly about the theoretical curves, the maximum discrepancy being about 5 per cent., whereas the points for the simply-supported specimens B tend to lie slightly below the theoretical curves. The experimental scatter is, however, greater than the differences between the various theories. Unfortunately the conditions of support for the B specimens proved to be weaker than was intended. Fig. 13 (*g*) and other similar patterns obtained show that yielding in fact occurred below the block through which the load was transmitted as well as to the right of it. This probably caused M/M_o to be lower than it would have been if the load had been applied directly to the beam, with a web stiffener below the load point.

For $\frac{F}{YA_w} > \frac{1}{\sqrt{3}}$, Leth's formula (12) clearly over-estimates M/M_o, sometimes by a large amount, while the curve $\frac{F}{YA_w} = \frac{1}{\sqrt{3}}$ suggested by Heyman and Dutton under-estimates M/M_o by as much as 10 per cent. in one case (using, of course, the loading line construction). However, the theoretical prediction of a rapid decrease of M/M_o with increasing F/YA_w greater than about $\frac{1}{\sqrt{3}}$ is clearly confirmed.

Most of the regions of deformation revealed by etching (Fig. 13) correspond only roughly to the modes of deformation suggested theoretically (Figs. 4 and 6). It should be borne in mind

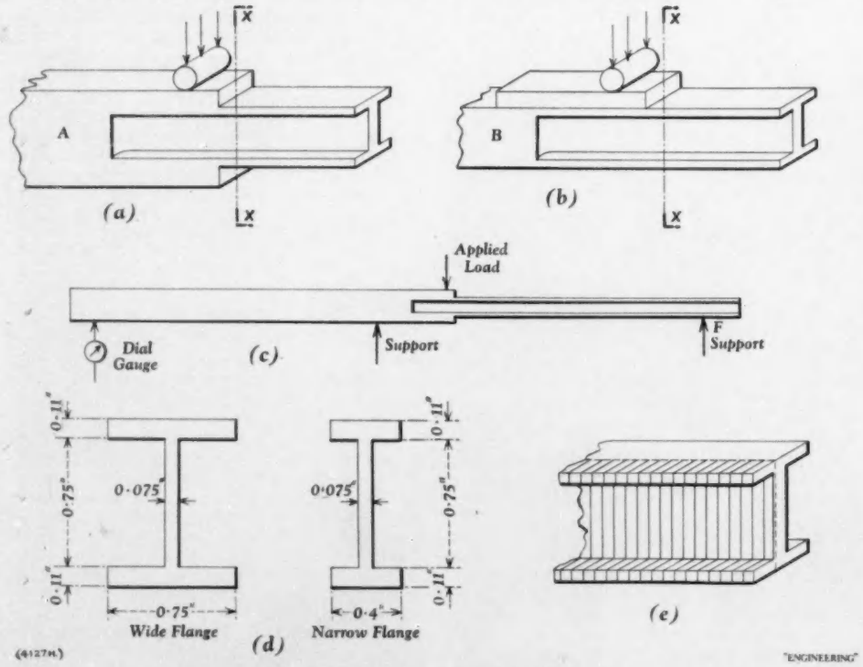


Fig. 8 Experiments on model I-beams.

(*a*) Specimens A, strong support.
(*b*) Specimens B, weak support.
(*c*) The three-point loading system.
(*d*) Nominal dimensions of cross-sections.
(*e*) Shaded material removed to examine deformation.

* Tube Investments Research Laboratories, Hinxton Hall, Cambridge.

† Steel, Peech and Tozer branch of the United Steel Companies, Sheffield. Formerly with the British Iron and Steel Research Association.

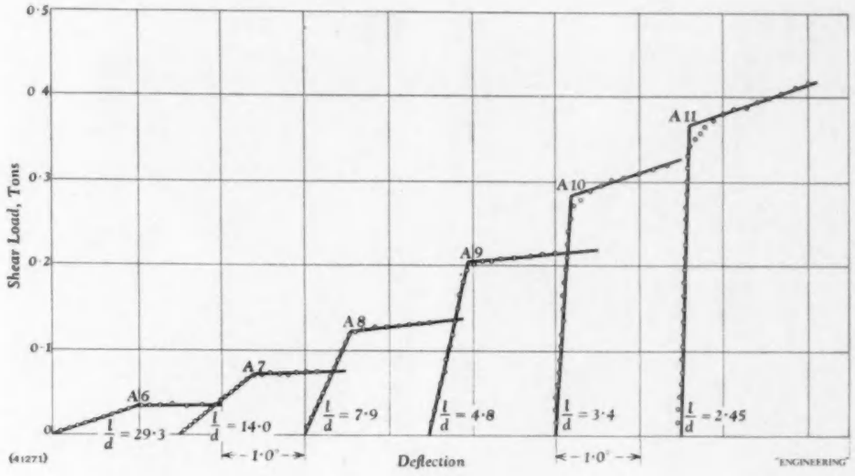


Fig. 9

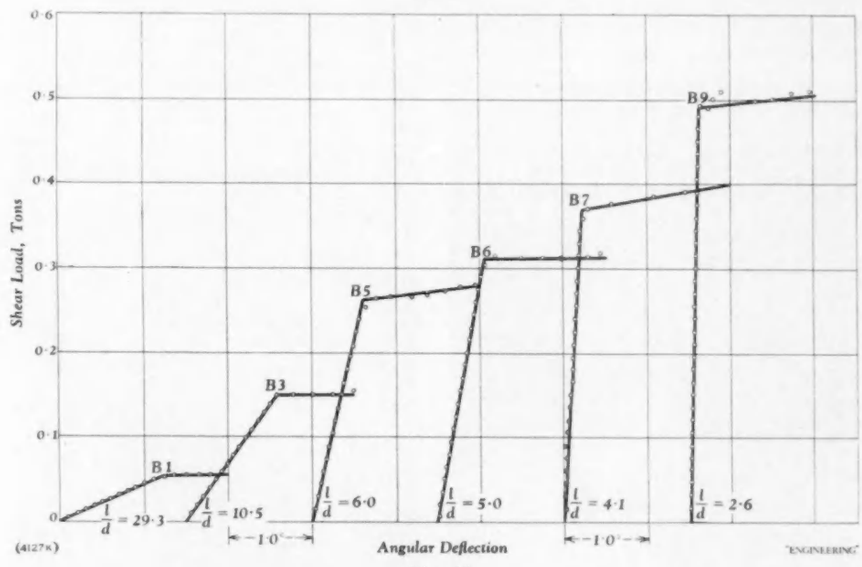


Fig. 10

Figs. 9 and 10 Typical load angular-deflection curves. Fig. 9 shows type A specimens with narrow flange; Fig. 10 shows type B specimens.

that the theoretical modes of deformation were primarily constructed to provide estimates of M, and are expected to correspond only qualitatively to actual deformation modes. The situation is complicated in practice by the peculiar nature of yielding in mild steel (the striations and curved pointed projections on the patterns are typical), and by the expansion of the deformed region due to work-hardening as deformation proceeds which makes it difficult to choose the stage of deformation that may best be compared with theory.

However, the experimental patterns do follow roughly the theoretical classification corresponding to Figs. 4 and 6. The type of etched pattern for a given loading line (that is, a given value of l/d) corresponded more or less closely to the type of pattern predicted theoretically. Only the patterns for strongly-supported beams A are compared with theory since the conditions of support for the type B specimens differed from any envisaged theoretically. The classification of types of deformation mode and the corresponding theoretical ranges of F/YA_w and of l/d for the dimensions of beams tested, are set out in Table I. The comparison between theory and experiment is made in Table II. It was impossible to distinguish experimentally between the theoretical sub-classification IIa and IIb.

It is perhaps worth mentioning that, under conditions of plane strain, the patterns produced by etching have more clearly-defined boundaries than under conditions of plane stress, such as in the web of an I-beam, and much closer agreement has been obtained with theoretical solutions.[9]

TABLE I.—*Types of Deformation Mode*

Type	I	IIa	IIb	III
Fig. No. ..	4a	4b	4c	6a or b
Range of F/YA_w	0→0·046	0·046→0·36	0·36→0·58	>0·58
Range of l/d.. (wide flanges)	∞→34·5	34·5→4·48	4·48→2·77	<2·77
Range of l/d.. (narrow flanges)	∞→19·0	19·0→2·47	2·47→1·53	<1·53

TABLE II.—*Comparison of Experimental and Theoretical Deformation Modes*

	Fig. No.	l/d	Type of pattern	
			Experiment	Theory
Wide flange	—	6·00	I + suspicion of II	IIa
	—	4·15	II	IIb
	11f	2·20	III	III
Narrow flange	11a	29·3	I	I
	—	14·0	I	IIa
	11b	7·9	I – II	IIa
	11c	4·8	II	IIa
	11d	3·4	II	IIa
	11e	2·45	II	IIb

DISCUSSION AND CONCLUSIONS

It seems reasonably certain that the relation between M and F for a cantilever of given cross-section is not seriously affected by the details of the conditions of loading and support. Both the calculations of Green for simple and strong end support and the experimental results shown in Fig. 11 bear out this conclusion.

The occurrence of an upper yield point on the load-deflection curves for the weakly-supported beams B, but not on those for the strongly-supported ones A, is probably due to the differences in uniformity of stress distribution. An upper yield-point will not be observed unless an appreciable proportion of the region of initial deformation yields simultaneously.

The model experiments reported in this article confirm and supplement other work so far as the relation between M and F is concerned. The experimental results of Heyman and Dutton[6] present much the same picture as Figs. 11 and 12 when plotted on the same basis, though there are fewer experimental points and the scatter is greater. All of the equations (7) to (11) combined with equation (5) agree tolerably well with the experiments in the range $0 < \frac{F}{YA_w} < \frac{1}{\sqrt{3}}$.

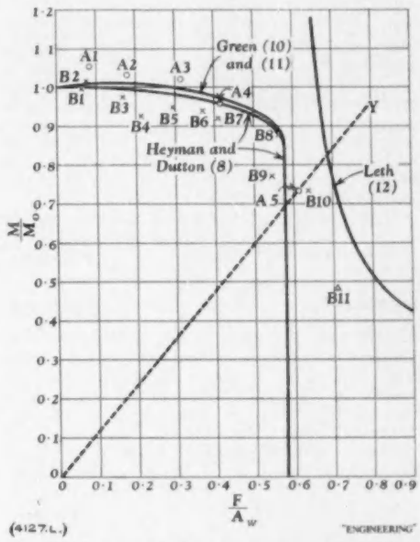


Fig. 11 Comparison of theory and experiment for I-beams with wide flanges ($\rho = 6{\cdot}40$).

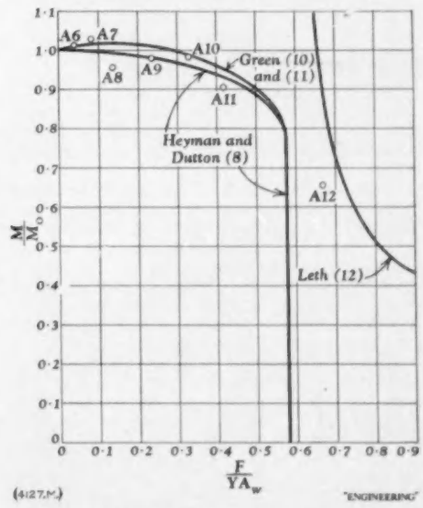


Fig. 12 Comparison of theory and experiment for I-beams with narrow flanges ($\rho = 3{\cdot}52$).

(a) $\frac{l}{d} = 29{\cdot}3$. Strong support (A), narrow flange.

(b $\frac{l}{d} = 7{\cdot}9$ Strong support (A), narrow flange.

(c) $\frac{l}{d} = 4{\cdot}8$. Strong support (A), narrow flange.

The equation (8) of Heyman and Dutton, however, has the advantage of simplicity and of covering the whole of this range. It also gives a more conservative and hence a safer estimate than Green's equations. For these reasons it is suggested that it is to be preferred for design purposes. It is clear that for the shapes of I-beams commonly used no correction to the simple theory of pure bending is required if F/YA_w is less than about 0·25.

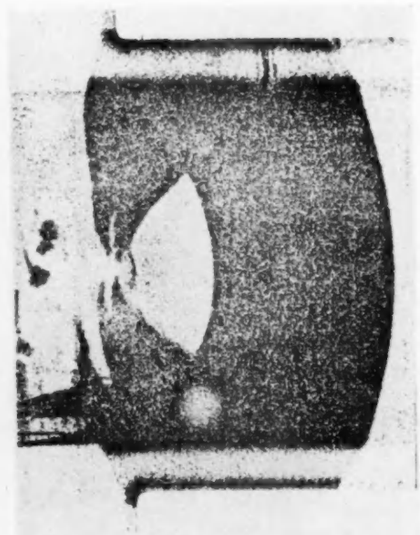
There is general agreement between theory and experiment that for $\frac{F}{YA_w} > \frac{1}{\sqrt{3}}$ (and correspondingly $\frac{l}{d} < \frac{\sqrt{3}\rho}{4}$) the value of M decreases rapidly with increasing F and yielding involves simple shear over an increasing amount of the web, tending to the mode of deformation suggested by Leth. In addition to the present experiments, tests by Heyman and Dutton, Johnston, Young and Beedle[10], and Baker and Roderick[1] all confirm this. There is at present no accurate theory in this range but here again Heyman and Dutton's method of estimating M, approximate though it is, gives a conservative and safe value.

APPENDIX

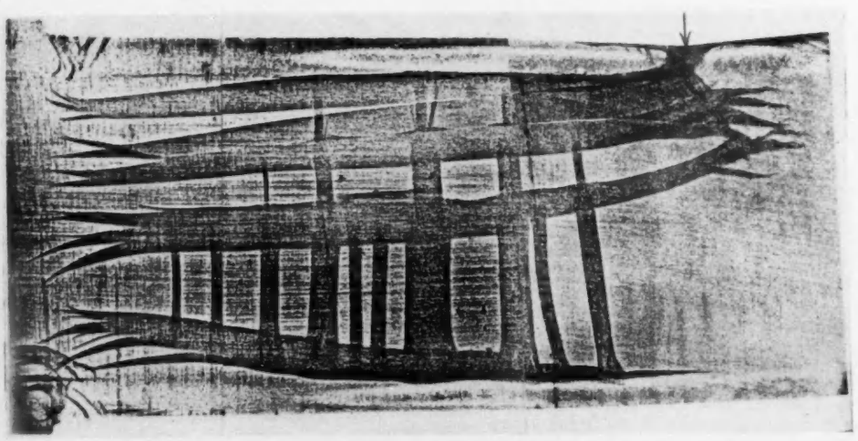
The estimation of limit loads in plasticity theory is based on the maximum-work principle for a finite body[2, 6]. Effectively, such loads are calculated for a plastic-rigid material (that is, one for which Young's modulus is infinite) and have the practical significance that the load for an actual material with finite rigidity may be raised very near to it and yet cause an overall permanent deformation of an elastic order of magnitude only.[7]

There are two kinds of incomplete solutions which, in problems such as the one under consideration, can provide either a lower or an upper boundary respectively to the applied loads:—(1) an equilibrium stress distribution covering the whole body which satisfies any given stress boundary conditions and nowhere violates the yield criterion provides a lower boundary; (2) a deformation mode which satisfies only the displacement boundary conditions can be used to obtain an upper boundary. A solution is only complete if it satisfies the conditions specified in both (1) and (2), and if in addition the stress distribution and deformation modes are compatible in the regions where deformation occurs, i.e., the stress-strain-rate relations are satisfied. It then provides the accurate and unique value of the limit load for a particular set of conditions of loading and support.

(d) $\frac{l}{d} = 3{\cdot}4$. Strong support (A), narrow flange.



(e) $\frac{l}{d} = 2{\cdot}45$. Strong support (A), narrow flange.



(f) $\frac{l}{d} = 2{\cdot}2$. Strong support (A), wide flange.

Fig. 13 Etched patterns showing regions of plastic deformation on sections cut parallel to the webs.

None of the solutions summarised in this article is a complete solution, and only the deformation mode of Leth,[11] or the modification suggested for a beam continuing beyond the load point, are incomplete solutions of the type defined. They satisfy, in fact, conditions (2) and therefore provide upper boundaries.

Horne's stress distribution[8] does not strictly satisfy condition (1), even for a cantilever of rectangular section and it certainly does not extend over the whole of an I-beam. Heyman and Dutton[5] believed erroneously that their solutions gave theoretical lower boundaries; but since they did not propose a stress distribution over the whole beam the fact that, according to experiments their load estimates are conservative, is fortuitous. Green's deformation modes[4] in the web provide upper boundaries for a cantilever of rectantular section; but they cannot be fitted to regions of pure tensile strain in the flanges, as demanded by the assumption that $M_F = M_{F0}$ and are not therefore strict upper boundary solutions for I-section cantilevers. Leth's stress fields cover the whole of the I-section cantilever but involve an approximation at the flange-web junction. None of these solutions, therefore, fits exactly the conditions necessary for upper or lower boundaries. However, as experiments show, the approximations involved in them are reasonable and the estimates they provide of the relation between M and F are a fair approximation for mild steel cantilevers.

Acknowledgments.—The authors thank Tube Investments Limited and United Steel Companies Limited for permission to publish. The experimental work was carried out while one of the authors was with the British Iron and Steel Research Association. The authors are grateful to Mr. T. D. Boxall, Mr. D. Burton, and Mr. B. Coldwell for help with experiments.

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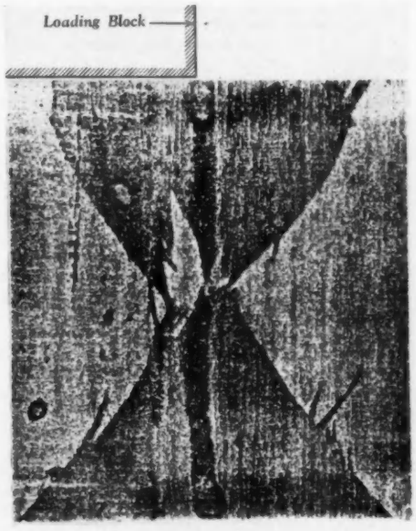
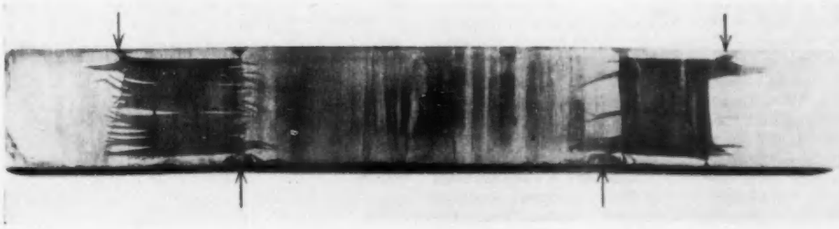


(*g*) $\frac{l}{d} = 8{\cdot}0$. Weak support (B), wide flange.



(*h*) $\frac{l}{d} = 1{\cdot}3$. Four-point oading.

UNDERGROUND CONDUITS FOR ELECTRICAL WORK

Effect of Surface and Backfill Loads

For many years the underground cable ducts employed by the Bell Telephone organisation in the United States have been principally made of vitrified clay and have shown adequate strength and durability under a wide variety of conditions. For some time, however, conduits of other materials have also been used; and to prevent possible failure of these an investigation has been carried out at the Outside Plant Development Laboratories of the organisation, Chester, New Jersey and Atlanta, Georgia, to determine their minimum strength under various field conditions.

An account of these investigations is given by Mr. G. F. Weissmann in the May issue of *The Bell System Technical Journal* in which he points out that the external loads to which underground conduits are subjected are due both to the weight of backfill material and to those applied at the surface. These loads produce circumferential bending moments in the conduit wall, to determine which the interors of thin walled aluminium or steel tubes about 4 in. in diameter and with wall thicknesses of 0·065 or 0·062 in. were fitted with a number of strain gauges. These enabled the strains in the tubes to be measured with an accuracy of $\pm 10 \times 10^{-6}$ in. per in. when they were attached to the interior of the tubes; and when the latter were laid lengthwise on the bottom of the trench between two pieces of plastic conduit of the same external diameter. The tubes were arranged so that one of the strain gauges was at the top of each tube and the trench was afterwards filled with backfill material. Loads at the surface were then applied by driving lorries with known weights to a halt over each tube or at a moderate speed across the trench. A 500 lb. weight was also dropped from different heights on to the surface of the fill.

MEASURED STRAINS AND APPLIED LOADS

As a result of several hundred tests with this equipment a straight line relationship was established between the measured strains and the applied loads. It was assumed that the strains caused by the compressive forces were small compared with those caused by the circumferential bending moments. The former were therefore neglected and relationships were established between the circumferential bending moments and fibre strains, details of which are set out in Mr. Weissmann's paper.

The moment of distribution under the tube may vary up to 235 per cent. if moist clay backfill is used, but is not affected when dry sand or gravel backfill is employed. The moments at the side points do not change by more than 12 per cent.

There was no significant variation in the bending moment when the width of the trench was between 18 and 30 in. The magnitude of these moments, in fact, appeared to be solely a function of the backfill material, the applied load and the height of the backfill over the conduit. For a 5 in. wide trench the bending moments were independent of the type of backfill. As backfill provided the main protection against loads applied at the surface the type used and its height over the conduit were important. The relationship between the bending moment in the conduit and the height of the backfill for different applied loads was therefore determined. The results showed that the maximum bending moments occurred in wet clay, but that these were reduced by increasing the height of the backfill or decreasing the applied load.

When lorries were driven over clay backfill at about 20 m.p.h. it was found that the bending moments due to the dynamic loads were equal to, or even smaller than, those obtained with static loads. With sand backfill, however, dynamic loads caused an increase in the maximum bending moments of about 10 per cent.

★ ★ ★

DISTILLING WATER ON A LARGE SCALE

We are informed that Richardsons, Westgarth and Company, Limited, Wallsend-on-Tyne, have developed an entirely new type of distilling plant producing pure water from sea water. Apparently, no technical data regarding the plant are available for publication but it is stated that the design is based on an exhaustive series of tests conducted under industrial operating conditions on large-size test rigs. Operating methods have been developed permitting the plant to be run continuously without being opened for cleaning and without loss of output due to scaling. Designs for outputs up to 1,000,000 gallons (4,500 tons) a day, in one unit, are available. An order recently received for a unit of this type is for installation in a refinery in Ecuador, South America. In view of the growing demand for fresh water in a number of arid territories, further orders for these plants are anticipated.

★ ★ ★

FLAME FAILURE EQUIPMENT

The range of Fireye flame-failure safeguard equipment is now being manufactured in this country by the Fireye Controls Company, Limited, 14 Fetter-lane, London, E.C.4.

The apparatus works on the principle of monitoring a flame by detecting the infra-red emanation from it. The safeguard consists of two units, the lead-sulphide cell scanner which monitors the flame, and the control unit which receives the signal from the cell and takes the necessary action. It can be arranged to give an alarm only, alarm plus shutting-off of fuel, or an integrated system which includes a relighting device to restore an extinguished flame.

THE DEVELOPMENT OF RUSSIAN PROPELLER TURBINES

Earlier this year, on the initiative of Professor Ackeret, a paper on "The Development of Russian Propeller Turbines" was read at the Federal Institute of Technology, Zürich, by Dipl. Ing. F. Brandner, and was reported in *Neue Zürcher Zeitung* of February 28; the present article is based on the Swiss report. Herr Brandner was one of the German jet engine designers who went to Russia after the war.

About 800 engineers from Junkers and B.M.W. who had been working on jet engine development were taken to Kuybychew (formerly called Samara, located where the Volga river crosses the 50th East meridian) in 1946. Junkers were at that time concerned with the development of a jet engine (Type 012) with a mass flow of 132 lb. per second, thrust 6,600 lb. and specific consumption 1·06 lb. per lb.-thrust per hour.

The German workers first built four test beds operating at outside temperatures of — 12 deg. F., which were used afterwards on a day and night basis. The technicians had no technical background at their disposal, and they had to take important decisions on their own responsibility, which naturally tended to make them somewhat conservative. The first compressor which they designed had the following main data: Number of stages, 12; pressure ratio, 4·5 to 1; mass flow, 132 lb. per sec.; speed, 6,000 r.p.m.; internal isentropic efficiency at design point, 83 per cent.; outer diameter, 30 in.; hub/tip ratio of the first stage, 0·45; tip speed, 797 ft. per sec.; first-stage reaction at tip, 89 per cent.

The stage temperature rise was deliberately chosen to be rather small, in spite of the larger number of stages that this would necessitate and this decision proved to be satisfactory. Tests showed that bleeding was necessary for starting the compressor. A good deal of work was done on blade vibrations. Lacking locally-produced heat-resistant materials, steels such as St.60 or the Krupp FKT.10 had to be used. At the outset it proved extremely difficult to build the casings because they were of welded construction with very tight tolerances. In order to achieve the smallest possible blade clearances, the inside of the casing wall was painted with a resinous layer of approximately 0·04 in. thickness which was rubbed away during running-in of the compressor, which necessitated running it at 15 to 20 per cent. above the design speed. The combustion chamber design was based on a new concept, and consisted of 12 primary chambers leading into a common annular secondary zone. The axial velocity was about 365 ft. per second resulting in a relatively large pressure loss of 7 per cent. and an efficiency of 95 per cent. The maximum diameter of this engine was 46 in. The project was cancelled in 1948 as a result of two blade failures, which were attributed to coarse grain structure in the high-temperature materials. As a result of these failures, the criterion for the upper limit of grain size of blade material was set at 0·02 in. A testing programme to investigate high-temperature creep strength and thermal shock properties was begun. It appeared during this development work that this project was intended merely as a means of setting up and running-in the research centre.

A new specification called for a propeller turbine with an output of 6,000 h.p. at an air speed of 520 m.p.h. The reduction gear was of the epicyclic type with a reduction ratio of 7 to 1, driving contra-rotating propellers of 12·75 ft. diameter. The technical data on this engine, known as the Type 022, after two years development, were as follows: Maximum diameter, 41·3 in.; maximum length, 177 in.; weight without propellers, 3,090 lb.; output, 5,700 h.p.; Net thrust, 1,320 lb.; total equivalent s.h.p., 6,250 h.p.; speed, 7,960 r.p.m.; specific fuel consumption, 0·54 lb. per e.s.h.p. per hr. The combustion chamber was of the type described above but had an axial velocity of only 288 ft. per second giving a pressure loss of 2½ per cent. and an efficiency of 98 per cent. At about this time, a parallel Russian development was cancelled and the German design team was asked to produce an engine with double the output. The first attempted solution to this demand was to couple two 6,000 h.p. engines together. Tupolev was responsible for the aircraft design in which this was to be installed. However, the design was unsuccessful and the flying test-bed crashed.

DESIGNED IN 3 MONTHS

The Russians did not, however, give up the 12,000 h.p. engine but issued a new specification known as the "K" engine. The German designers had to complete the preliminary design and take full responsibility for it in three months. The specification was as follows:— Design altitude, 36,000 ft.; output at altitude, 8,000 h.p.; output on the ground, 12,000 h.p.; jet thrust, 2,650 lb.; speed, 8,250 r.p.m.; specific fuel consumption at altitude, 0·353 lb. per e.s.h.p. per hour; specific fuel consumption on the ground, 0·574 lb. per e.s.h.p. per hour; maximum outside diameter, 45·3 in.; maximum length, 238 in.; weight without propellers, 5,070 lb.

Despite the fact that the mass flow of the 12,000 h.p. engine had had to be doubled, the outside diameter was not allowed to be increased above that of the 6,000 h.p. engine. This necessitated a very small hub diameter which was limited ultimately by bearing size. The aerodynamic problems associated with this proved difficult and are even now not completely solved. It was not permitted to reduce the tip speed and use more stages. The Mach number at the tip of the first stage reached 0·88. The aerodynamic centre of the first three stages was moved back as far as possible and allowed to come forward to between 20 and 50 per cent. of the chord in later stages. Some N.A.C.A. data was used in this design. The drum form was a straight cone but the outer casing was made up of two cones of different angles. The compressor had an internal isentropic efficiency of 86 per cent. at the design point on the ground which it was hoped would rise to 88 per cent. at altitude.

The compressor casing was of welded construction, made from 0·079 in. thick rolled material with a horizontal joint. The casing was reinforced by U-shaped sections which also served to locate the U-shaped stator rings. The latter were fixed to the casing by means of six screws per stage. The holes for the blades in the stator rings were either punched or spark-machined, the blades being welded into these holes and into the inner stator shroud rings. The rotor consisted of discs and tubular connecting pieces bolted together and, by 1952, they were made of Titan steel. The moving blades were fixed by dovetail slots and screws. Initially, the blades for the first three stages were made of light alloy but later, due to icing troubles, all moving blades were made of steel. The sub-contracting of manufacture and other factors were found to result in inaccuracies which adversely affected the efficiency and surge limits of the compressor. Balancing of the compressor was supposed to be within 0·55 oz.-in. but in practice unbalance as high as 7·1 oz.-in. did not cause rough running. Since the design pressure ratio at altitude was 13, bleeding as well as automatically-adjustable inlet guide vanes were necessary for starting. The compressor rotor was mounted on a front roller bearing and a ball bearing at the rear which took the residual thrust. The bearings were also made at the research centre, because of difficulties experienced with cages. The gear-casing ribs were heated by oil and compressed air in order to avoid icing. Oil sealing proved difficult, and loss of efficiency was experienced due to dirt sticking to the blading. Comparative compressor data for the two types of engine are as follows:—

Type	6,000 h.p.	12,000 h.p.
Number of stages	14	14
Tip speed, ft./sec.	764	990
Rotor outside diameter, in.	24·88/24·25	29·23/24·88
Hub/tip ratio (1st stage)	0·6	0·453
Mass flow, lb./sec.	66	136
Pressure ratio	6·0 : 1	13·0 : 1 at altitude 9·5 : 1 on ground
Reaction (1st stage tip)	0·89	0·62
Isentropic (internal) efficiency (design point)	0·87	0·86

COMBUSTION CHAMBER

A combustion test rig was used with an electrically-driven compressor, which was sufficient for a single combustion chamber but which could not quite simulate the full altitude conditions. An efficiency of 98·5 per cent. was obtained with a system similar to that used in previous engines. The entrance velocity was about 164 ft. per sec. and the leaving velocity 426 ft. per sec., giving a pressure loss of 3½ per cent. The life of the combustion chamber was between 300 and 500 hours. The whole combustion chamber was constructed of 0·04 to 0·06 in. thick scale-resistant sheet. The weight of the combustion chamber was 97 lb. Most of the combustion testing was carried out under acceleration and deceleration conditions which was considered to be more representative of the most severe operation than steady conditions.

In order to achieve the smallest possible number of turbine stages, high tip speeds giving large stage heat drops, with mean blade speeds of 985 to 1,080 ft. per sec. were used and heat drops of 139 C.H.U. per lb. were achieved. The stage heat drops fell in the direction of flow. It proved very difficult to attain internal isentropic efficiencies in the region of 90 to 93 per cent. In order to achieve the smallest possible radial clearances, the inner wall of the turbine casing was lined with carbon or carbon blocks so that rubs were not serious. However, this could only be done for temperatures below 650 deg. C.

The turbine casing was constructed on the same principle as the compressor casing. The inner and outer U-shaped rings for the stator blades were pressed from 0·078 in. plate. The blades were welded to the outer ring but were free to expand in the inner ring. The first row of stator blades was cast in a cobalt alloy. All stationary stages had constant flow angles. The untwisted moving blades were milled in a horizontal milling machine and were fixed to the discs with fir-tree roots which was particularly difficult because of the lack of special broaching equipment. In order to reduce the notch sensitivity of the heat-resistant materials, the blades were given a high polish. The blading material was a Russian copy of Nimonic 95. Successful tests with ceramic materials and cermets were carried out. After 1953, Russian-copied Nimonic alloys were also used for the discs which previously had been made of austenitic steels giving a life of only 300 hours. Whereas on normal endurance running no blade failures were experienced, this was not the case during acceleration trials when thermal stress cracks developed. In spite of the minimum trailing-edge thickness of 0·047 in. recrystallisation could only be avoided by care in the casting technique. The turbine data for the two types of engine were as follows:—

Type	6,000 h.p.	12,000 h.p.
Number of stages	3	5
Temperature at turbine inlet, deg. C.	760	880 at altitude 660 on the ground
Outside diameter, in.	26·77	27·56
Hub/tip ratio (1st stage)	0·85	0·85
Reaction	0·40 1st stage	0·20 1st stage 0·40 5th stage
Internal isentropic efficiency	0·9	0·94 at altitude

The starting of the 12,000 h.p. engine was by means of an auxiliary gas-turbine fitted along

the compressor casing. This engine consisted of a radial compressor, spiral combustion chamber, turbine and epicyclic reduction gear. The drive was through bevel gearing. The calculated starting power was 35 h.p. but 65 h.p. was used. The starter weighed 101 lb. with a maximum length of 29½ in. and a diameter of 11·8 in. Its compressor efficiency was 80 per cent. and turbine efficiency 81 per cent. The contra-rotating variable pitch and reversible propellers were entirely of Russian origin. They could be feathered in 2 to 3 seconds.

HIGH POWER, LOW CONSUMPTION

Comparison of the 12,000 h.p. engine with Western engines shows that the specific fuel consumption is fairly close to that of the Bristol Orion. The specific weight is similar to that of the Western engines but the specific power is extremely high. Development of the Russian engine was completed in 1954 and the engine is in service in the Tupolev bomber whose code name is "Bear." Type testing of new engines in Russia is extremely thorough consisting of at least six to eight 100 hour runs. Designers and manufacturers are made to take direct personal responsibility for defects. The German engineers have played a major part in the development in Russian propeller-turbine engines, but development of pure jet engines has been carried out mainly by Russian engineers. Jet engines of entirely Russian design with thrusts of 17,600 lb. should be available by now.

Labour organisation in Russia is of a nature only conceivable in the Western world in wartime. The present high level of Russian technology is due mainly to this ruthless system. The remarkable performance of the 800 engineers who were taken to Russia as "volunteers" is a result of their self-preservation instinct (for themselves and their families) which has acted as a spur to their technical abilities.

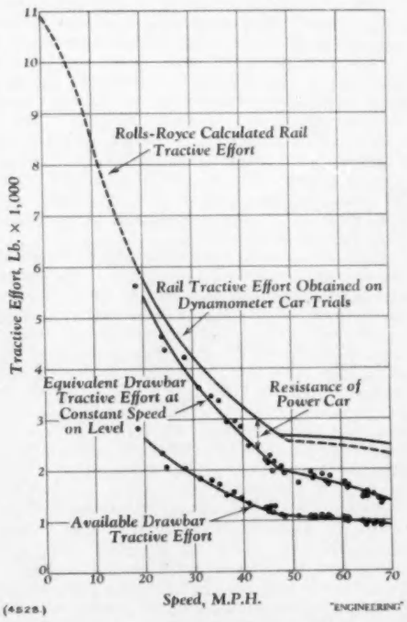
RAIL-CAR TESTS

A report on the trials of a two-car multiple unit set has been released by the British Transport Commission. The two-car set comprised a motor coach with two Rolls-Royce 238 h.p. engines (type C8NFH) and a driving trailer. The transmission utilises a three-stage torque converter with direct drive at the higher road speeds. The test sections chosen were the steeply graded Manchester/Rochdale via Middleton and Eldon, and the Carlisle/Skipton routes. On the Manchester/Rochdale line the chief incline is at Werneth, where there is three-quarters of a mile of one in 27, and on the Carlisle/Skipton line there is an incline of approximately 15 miles in each direction with ruling gradients of 1 in 100.

The two coaches were loaded with 11 tons of brake-blocks to represent 200 passengers, thus giving a gross train weight of 83 tons. The loads were varied at different times with the object of checking the torque converter fluid temperature at different powers and speeds. Running times and speeds proved entirely satisfactory, and were somewhat better than estimated from the design figures. The two coaches started from rest without slipping on the Werneth incline, and reached a balancing speed of 14 m.p.h. on this gradient. On the Carlisle/Skipton route, with 57 tons tail load behind the driving trailer, the train repeatedly started from rest on the 1 in 100 gradient without slipping, and the balancing speed was approximately 31 m.p.h. on the 1 in 100 gradient.

The 12 mile climb from Grizeburn to Aisgill on a ruling gradient of 1 in 100 was covered in 17¼ minutes at a speed of 41¾ m.p.h. The balancing speed on the 1 in 100 gradient was approximately 44 m.p.h.

Draw-bar tractive efforts were obtained by using a dynamometer car. Only one test has been analysed in detail and the results agree very closely with the design figures. The curves are shown in the accompanying diagram. A total mileage of approximately 1,700 was covered during tests without mechanical defect.



Tractive effort curves for the B.T.C.'s new two-car Diesel set.

* * *

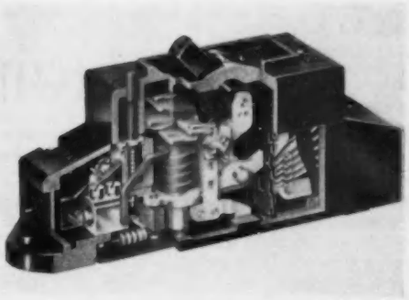
SMALL EARTH-LEAKAGE CIRCUIT-BREAKER

A Versatile Control Device

A double-pole earth-leakage circuit-breaker, which has recently been introduced by J. A. Crabtree and Company, Limited, Walsall, Staffordshire, complies with British Standard Specification No. 842, the Institution of Electrical Engineers Wiring Regulations and with the same body's memorandum on electrical installations in caravans. It is designed to perform all the functions carried out by the conventional main fuse, main switch and earth-leakage trip combination and this provides a convenient method of sub-circuit control with greater compactness and economy.

The standard pattern has a rating of 60 amperes at 500 volts alternating current, but units with overload and short-circuit features with ratings of 15, 30 and 45 amperes can be supplied. Tests have shown that the rupturing capacity was 3,500 amperes at 250 volts with a power factor of 0·45 and 3,000 amperes at 500 volts with a power factor of 0·6. In both cases the operating fault current was about 35 milliamperes.

As will be seen from the cut-away view reproduced herewith, the operating mechanism and arc chambers of this earth leakage circuit-breaker are separated from each other and from the cable terminals and fixing screws. The arc chambers themselves contain quenching grids and are provided with baffles which ensure that they are closed at all times regardless of the position of the moving contacts. The number of moving parts is small and their action is positive both on the "make" and "break." The handle is "trip-free" and cannot assume the "off" position unless the contacts are separated. The mechanism incorporates a switch which is operated by a push button and is used to check the continuity of the earth paths, the performance of the mechanism and also the operation of the unit in the correct order of sensitivity.



Cut-away view of new Crabtree earth-leakage circuit-breaker.

Tripping under overload and short-circuit conditions is achieved by an hermetically-sealed time-delay device embodying a magnetic-hydraulic principle which gives discriminating protection. As the silicone fluid used in this mechanism has a substantially flat temperature-viscosity characteristic the degree of overload protection is little affected by variations in ambient temperature.

* * *

TAPPING INTO THIN-WALLED PIPE

An unusual use of one of the hard metals has made it possible for an American company to substitute thin-walled gas pipe for the more expensive heavier pipe used in the manufacture of gas manifolds for water heaters. As the wall of the proposed ⅜ in. tube was only $\frac{1}{32}$ in. thick it was necessary to find a way to thicken it locally round a hole to enable a sufficient number of threads to be tapped into it. The manufacturers, Mission Appliance Corporation, Hawthorne, California, solved the problem by spinning smaller holes to tapping size and thickness with a titanium carbide rod made by Kennametal, Inc., Latrobe, Pennsylvania.

The operation is simple. The rod, 0·343 in. diameter and 3½ in. long, has a ball nose ground on it, and it is mounted in the chuck of an ordinary drilling machine. It is rotated at 2,000 r.p.m., and flame heated to about 1,200 deg. F., while it is forced into ¼ in. diameter punched holes in the pipe. During this operation the rod reaches white heat, approximately 2,000 deg. F., and the metal round the hole is thickened to ¼ in. as it is pushed inwards. About 3,000 holes can be spun before the ball end of the rod needs re-grinding.

By spinning a smaller hole to tapping size it is possible to use much thinner-walled tube than would otherwise provide sufficient metal for threading.

Book Reviews

CHALLENGING MACHINE

The Helicopter. By JACOB SHAPIRO. *Frederick Muller, Limited, Ludgate House, 110 Fleet-street, London, E.C.4.* (21*s.*)

In spite of the appearance of remarkable direct jet-lift devices like the Atar Volant, for example, which was recently demonstrated so effectively at Le Bourget, there seems little doubt that the pure helicopter and its immediate derivatives will play an increasing part in the field of air transport, in its broadest sense, for many, many years to come. Indeed the helicopter may generate an entirely new large-volume air traffic in that part of the travel spectrum—distances up to 200 miles—which at the moment is virtually entirely dealt with by surface transport alone. Even the current relatively small helicopters are tackling a great variety of tasks with savings in manpower, capital expenditure, and, above all, time. One need only recall the big part played by the helicopter in the development of the great aluminium project in British Columbia, in oil-prospecting in the Persian Gulf, and in exploration work in both Polar regions to appreciate that this new vehicle possesses special advantages owned by none other.

Mr. Shapiro, in an earlier book (*Principles of Helicopter Engineering*) essayed successfully the difficult task of presenting in one volume a technical treatise on all aspects of helicopter theory, design, manufacture and operation. This was a book to serve the several needs of a wide band of different specialists. In *The Helicopter* he has approached the same broad subject with entirely different people in view, " the many thinking and informed readers who wish to acquire their own judgment on a subject of present and future importance." After a discursive introduction, successive chapters are devoted to the language and terminology employed (a very necessary beginning), to a description of the working of a typical helicopter, then, to round off this first part of the book, to an absorbingly fascinating historical section. It is specially interesting to recall that the first production order for an Allied helicopter was of the Sikorsky R.4 for the Royal Navy. From this historic order has sprung the line of successful Sikorsky machines as we know them to-day. This section, however, could have had a few more illustrations—and of a better quality—to show the successive stages of development.

Chapters follow on the principles of vertical flying, analysis of the rotating wing, and the efficiency of flying. In this group Mr. Shapiro endeavours to explain the underlying theory of the fundamentals of flight, drawing distinctions and parallels, as necessary, between fixed-wing and rotary-wing aircraft. The ideas to be put across may be a little difficult to the non-technical reader, and in places the writer seems to have devoted rather too much attention to aspects which could have been dealt with in less detail. But he has entirely avoided the use of formulae, however simple. Although this approach may have a great deal to commend it, the objectives of these chapters could have been gained more clearly and economically by presenting the result of the main stages of the theory by a simple formula. After all, his " thinking and informed " readers need not be engineers to understand the elementary mathematics involved. Also, greater recourse to simple illustrations would have assisted the development of the arguments. On the whole, however, these fundamental chapters deal well with a subject which has been the subject of several extensive and learned scientific books. The directness of a sentence on page 125 has much to commend it: " Only the helicopter can achieve vertical flight consistently, safely and economically. No challenge is even remotely in sight." Chapters are then devoted to the design of, and uses for, the helicopter, with final sections on the outlook for the helicopter, and the improvement in communications by vertical flight.

In the last chapter, Mr. Shapiro conducts some interesting cost studies of the helicopter *vis-à-vis* road transport, with some stimulating and provocative conclusions. For example, the elapsed time on inter-city services 100–300 miles apart could, he contends, be quartered by using a fleet of helicopters as against a fleet of buses to meet the same traffic demand for a cost less than half as much again. Similarly, a personal helicopter, it is claimed, can be made less costly to run than a luxury car, assuming both to be equally utilised and both chauffeur-driven business vehicles. If such an economic argument can be sustained—and to do so will require a very considerable revolution in prime cost of the helicopter when compared with current machines—then a huge market awaits the successful manufacturer.

Mr. Shapiro has made a very creditable attempt to explain the helicopter in all its aspects to an intelligent reader. Many of the arguments and claims are contentious, but the book is none the worse for that. For the price, it may be felt that the diagrams and paper could have been improved; nor is there an index. But these are relatively minor shortcomings of an interesting book.

CURRENT INTERRUPTIONS

Switchgear Principles. By P. H. G. CRANE. *Cleaver-Hume Press, Limited, 31 Wright's-lane, Kensington, London, W.8.* (25*s.*)

In the early days of the electrical industry when power stations were small and interconnections rare, switchgear design was in the hands of a few pioneers who could rely only on their commonsense, and perhaps an inborn intuition for fitness of purpose of the gear for the conditions at that time. An early example was the Ferranti 10 kV alternating current circuit-breaker where the operator was provided with a paddle on a long handle so that he could fan the arc out—surely the earliest example of an " air blast " breaker.

Improvements were slow until, in the early 1920's when the plain-break oil circuit-breaker was universally used, the growth in the size of power stations, the need for interconnection and the desire for a more adequate theory led to research by the E.R.A. and others inquiring into the principles of circuit interruption. The researches started at the pioneer test station, at Newcastle, on plain-break oil breakers and led to the cross-jet explosion pot circuit-breaker and to the air-blast circuit-breaker, both of which were the subject of E.R.A. patents.

While this search for knowledge was going on, manufacturers began to feel the need for the means to test their products under controlled full-scale short-circuit conditions, and this led to the first commercial testing station at Hebburn—opened in 1929. Short-circuit tests were first specified in a British Standard Specification in 1937 (B.S.116:1937) and a further specification was issued in 1940 (B.S.936), to cover oil circuit-breakers up to 660 volts.

The theory and practice of modern circuit-breaking techniques, starting as they did in 1920, have reached the stage where there is a considerable fund of knowledge and it is of great importance to those engaged in the industry to know of the problems involved and the latest developments which may help to solve them.

The book under review will thus fill a need, as it sets out in one concise volume, the problems encountered and describes examples of gear designed to meet them. It deals with the requirements set by modern generation and distribution practice and enumerates the various normal and fault conditions which switchgear may be called upon to deal with under service conditions.

The simpler systems of protection are dealt with and serve as an introduction to the subject. The main body of the book is devoted, quite rightly, to the principles of circuit-breaking and to the various types of circuit-breaker available which will deal, each in its particular field, with system conditions of to-day. The final chapter is devoted to the important subject of tests and specifications and explains the test requirements of B.S.116:1952 in clear terms, which will be found most valuable to students and others seeking an introduction to the subject. In this connection it would perhaps have been better to have given a fuller explanation of test impulse voltage than that it " should be a standard 1/50 wave." Oil switches are now covered by a separate specification, B.S.2631:1955, and no doubt the author will correct the reference to B.S.116:1937 in the second edition.

The author is careful to point out that processes involved in the arcing phenomena are not yet fully understood and thus it is not yet possible to solve completely problems of breaking capacity. Research is still being carried on by the E.R.A. and by the research departments of the various manufacturers concerned. Whether or not the complete solution will ever be achieved by conventional means or by a method new to power engineering, such as by the use of ignitrons, does not detract from the value of the book. A carefully compiled bibliography is included for those who wish to make a more detailed study of the subject.

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BELOW WATER AND NEAR AIRCRAFT

Technical Aspects of Sound. Vol. II. Ultrasonic Range, Underwater Acoustics. Edited by E. G. RICHARDSON. *Cleaver-Hume Press, Limited, 31 Wright's-lane, Kensington, London, W.8.* (70*s.*)

The previous volume of this work, published in 1953, was concerned with the sonic range and chiefly with airborne sounds. The present volume is mainly devoted to the ultrasonic range and is more particularly concerned with underwater acoustics. The introductory chapter on the propagation of sound in the atmosphere and the sea is contributed by the editor. It deals with reflection and refraction effects, long distance propagation through air and water—with special reference to the temperature gradients responsible for zones of silence in air and sound channel effects in water—the influence of humidity upon the absorption of airborne sound, and scattering due to fine structure of atmospheric turbulence near the ground.

A comprehensive treatment of ultrasonic transducers and their applications, by B. E. Noltingk and N. B. Terry, occupies the first main division of the book. The major part of this is devoted to piezo-electric and magnetostrictive effects, since these provide the chief means of generating ultrasonic radiation. Magnetostrictive transducers bridge the frequency range from 10 to 100 kc/s, while piezo electric transducers are more suitable at higher frequencies. Although quartz is not the most effective piezo-electric material it is still one of the most important on account of its mechanical stability and almost negligible internal damping. It is accordingly treated in some detail before the more widely used materials, such as Rochelle salt and ammonium dihydrogen phosphate, are dealt with. Considerable space is allotted to the electrostrictive effect in barium titanate. Eauivalent circuits of magnetostrictive transducers are worked out fully. Various types of receivers and detectors of ultrasonic radiation are described, including

those based on optical and thermal methods of detection. The comprehensive survey of ultrasonic applications includes sections on inspection and communication systems, mechanical applications, effects in liquids, chemical effects, biological and therapeutical applications and miscellaneous uses.

The second division, on underwater acoustics, brings out clearly the difference between underwater and air acoustics. It begins with two chapters by E. Meyer, the first outlining the appropriate measuring techniques and describing the associated equipment; the second dealing with air bubbles in water which, because of their large compressibility, materially alter the sound velocity and give rise to more or less pronounced attenuation. Experiments involving progressive waves can only be undertaken in water tanks of finite size when reflections from their walls have been reduced to a minimum, by lining them with suitable broad-band absorbers. Materials and constructions serving this purpose have been thoroughly investigated at Göttingen by K. Tamm, who reports on them in chapter 6. An elegant alternative method of cutting down reflections is to employ resonant sound absorbers. These are discussed by H. Oberst. Applied to the hulls of submarines in the form of rubber sheeting consisting of two superimposed layers, 2 mm. thick, the inner one perforated with cylindrical holes, these helped to prevent the detection of submerged submarines by the absorption of the ultrasonic beams which would otherwise be reflected to the detectors of the hunting vessel.

The main portion of the third division is devoted to three chapters by A. A. Regier, H. H. Hubbard and L. W. Lassiter on aircraft noise which, near aeroplanes now in service, has risen to levels exceeding human tolerance. Factors responsible for both propeller and jet noise are analysed, as well as those responsible for other sources of noise—such as the sonic bangs. There is a useful comparison of noise levels from various aircraft propulsive systems, but much remains to be discovered about means for reducing them.

The concluding chapter on sounds of propulsion in water, by the editor, deals with such matters as high-speed cavitation and the "singing" propeller. A useful feature is the indication of the page containing the references—relegated to the ends of the chapter—at the foot of every page of the text. Though the various contributions differ considerably in method of presentation and depth of treatment, they do, on the whole, provide a most interesting and informative account of the more important physical and technical aspects of underwater acoustics and aircraft noise.

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NEW BOOKS

Metrology and Gauging. By S. A. J. PARSONS. *Macdonald and Evans, Limited, 8 John-street, Bedford-row, London, W.C.*1. (25*s.*)

Based on lectures delivered to advanced students at the College of Technology, Birmingham, the text has been considerably increased by further information. The aim is to provide a knowledge of basic principles and then to present a survey of the latest developments. The text has been prepared to cover the syllabus requirements of the Institutions of Mechanical Engineers and of Production Engineers in the subject of metrology. It also covers Higher National Certificate courses for mechanical and production engineering.

Metal Machining. By LAWRENCE DOYLE. *Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.*1. (75*s.*)

In his preface the author states that the purpose of the book is to acquaint the engineer, or the prospective engineer, with the machning area of production processing from the engineering viewpoint. There are two facets. The first explains the reasons for the practices, methods, details and machines found in industry and forms the basis for this book, and the second makes use of principles to adapt such practices to produce efficiently. The book covers instruments, gauges, the action of cutting tools in general, and then goes on to consider different types of machines in particular. The chapters end with a number of questions and a list of references.

Farm Mechanization Handbook. By T. HAMMOND CRADOCK. *Temple Press, Limited, Bowling Green-lane, London, E.C.*1. (25*s.*)

This, the third edition, contains 14 more chapters, and the text of the earlier ones has been enlarged and revised. More details are given of equipment that has been added to the farm since the earlier editions appeared, and the perspective drawings of popular types of tractors, harvesters and balers are included. Technical and service details of most of the engines are listed.

The Direction of Research Establishments. Proceedings of a Symposium held at the National Physical Laboratory on 26th, 27th and 28th September, 1956. *H.M. Stationery Office, York House, Kingsway, London, W.C.*2. (25*s.*)

It was felt by the authorities of the N.P.L. that a consideration of the wise management of scientific resources was a matter of outstanding importance at the present time, and it was accordingly decided to devote this symposium, the seventh of the present series being held under the Laboratory's auspices, to developing a greater understanding of the many difficult problems that confront research administrators. In all, 20 papers were read and discussed at the three-day conference, which was attended by 173 delegates representing 16 countries. The papers and the comments thereon dealt with such aspects as the choice of research projects, staff selection, personalities needed for creative work, difficulties of supervisors, building requirements, financial considerations, and a discussion of the best means of passing on the results of research to other scientists, to industry, and to the public generally. Altogether, they represent a very thorough review of the whole subject. Articles on the symposium appeared in ENGINEERING, November 16, 1956, page 617; November 30, 1956, page 681; and December 14, 1956, page 749.

Nuclear Power Year Book, 1957-58. Edited by WILLIAM DAVIDSON. *Rowse Muir Publications, Limited, 3 Percy-street, London, W.*1. (42*s.*)

This is the first edition of a year book covering the nuclear power industry. As well as 13 review articles, the book contains the following sections: world authorities, giving names and addresses and details of future programmes; technical data; isotopes; company addresses; buyers' guide; trade names; and who's who in British nuclear energy. The review articles cover such subjects as: the British nuclear groups, nucleonic instrumentation, mining of uranium minerals, zirconium as a constructional material, recent advances in nuclear physics, and atomic energy and the law.

On the Shelf

By Frank H. Smith

When one relaxes in one's favourite easy chair to watch the latest offering on the cathode-ray screen one tends to forget (if one ever knew) that one's fundamental comfort is due, not to pure chance, but to quite a lot of research. This research is carried out, not only by the individual firm that made the chair but also by the Furniture Development Council, one of the liveliest of all the co-operative research bodies.

Some time ago the daily Press gave some publicity to a piece of apparatus which measured the strain on a chair subjected to the bouncings of a very overweight man over a period in excess of any such man's lifetime. A good armchair is expected to stand up to it. The latest *F.D.C. Newsletter* (No. 11 May) gives outlines of recent researches which the Council have made on behalf of the industry. There are brief descriptions of tests for lacquers before use, a list of information-inquiries received (oil finish for mahogany, glue penetration through veneer, identification of grub found in upholstery, and many others) and a questionnaire on chipboard, and much else of interest, not only to the furniture manufacturer but to others with dealings in timber, upholstery fillings and kindred subjects. The Research and Technical Information Service is at 2–4 Dalmeny-avenue, London, N.7.

Firth Brown News for the summer, 1957, is a typical house magazine with a very high standard of photography. There is a nicely balanced selection of staff news and articles on the firm's interests and products. Bowing to fashion, there is a "Profile" and I mention this only because, in this case, it is of "The Office Boy"; it consists of three lines of text and an excellent photograph of a nice looking youngster. I would suggest to the editorial staff that the *News* be given some sort of serial number in future.

There is a plenitude of information on the subject of ceramics generally but not such a wealth on ceramic tools. The Department of Mechanical Engineering of the Royal Technical College of Salford has, therefore, performed a service in producing a bibliography, edited by a senior lecturer, R. C. Brewer, on this particular branch. Arranged in alphabetical order of authors, the list runs to 131 references.

The Economic Commission for Europe of the United Nations has published the first volume of *Annual Bulletin of Gas Statistics for Europe*. Consisting of 20 pages it costs 2*s.* and is obtainable from H.M. Stationery Office.

The catalogues of second-hand booksellers are always welcome. You never know what treasures you will find—somebody else's "junk" may be just what you are looking for. Mr. H. Pordes, 138 New Cavendish-street, W.1, produces a particularly well-filled catalogue and any one looking for a run of *The Times* from 1837 to 1945, bound in calf and buckram, can obtain it, complete with the official index 1836–1945, for a mere £3,750.

From time to time a large bundle of literature arrives from the American Society for Testing Materials announcing its new and "in-print" items. To save wading through the complete catalogue, there is a separate sheet listing "New Books Covered in this Booklet for the First Time." This includes the *Five-Year Index* (1951–5) at 3.50 dols. which complements the previous 50-Year Index; *Methods for Chemical Analysis of Metals* at 8 dols.; *Industrial Chemistry, Properties and Applications of Silicones* at 1.50 dols.; nine different symposia published in the STP (Special Technical Publications) series and several other publications. A separate tract lists the whole of the STP from 1898 to 1956 and "Symposiums or Topical Discussions," for the same period. I do not know why they specify 1898. The earliest date I could find was 1911.

The prestige material issued by the oil companies is always a joy to the beholder, be it printed matter or film. The June *Shell Magazine* celebrates 50 years of progress by the Royal Dutch-Shell group.

Many old-timers in the aeronautical world still think of *The Aeroplane Directory* as *Who's Who in Aviation*—the name by which the directory was first published. The same people will now have to alter their ideas concerning the *American Aviation World-Wide Directory*. It has become *World Aviation Directory* and the Spring/Summer edition is available at 10 dols.

The Engineering Institute of Canada has caught the "Annual Review" fever and the *Engineering Journal* for May "presents a record of Canada's engineering and industrial achievements in 1956." As the word Canada is nowadays synonymous with emigration, this issue is likely to be of interest to quite a wide readership. The Institute, by the way, celebrates its 70th anniversary this summer and it must be particularly gratifying for it to be able to publish a journal that is one long record of "up and up."

Soviet News, 3 Rosary-gardens, London, S.W.7, have published a neat little booklet, costing 6*d.*, entitled *Training Technicians in the Soviet Union*. It is quite interesting and contains some impressive statistics.

CONVEYOR BELT GUIDE

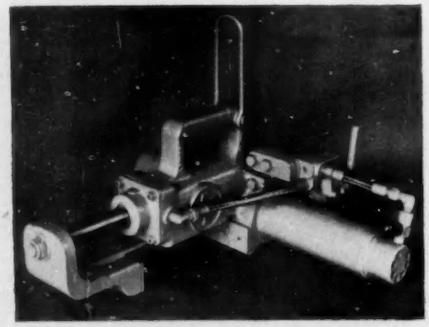
Damage is frequently caused to the edges of conveyor belts, either by faulty aligning or by abuse, and to protect them, and maintain the true path, a guide pulley known as the " Guidler" has been introduced. Its distribution in this country is in the hands of the British Wedge Wire Company, Limited, Academy-street, Warrington, Lancashire. The particular feature is the double conical shape, which, it is claimed, does not damage belt edges as cylindrical guides can do, and enables belts to continue in use long after they would otherwise have been scrapped. It is shown in the illustration fitted beside an ordinary support roller on a belt.

The body of the Guidler is a Meehanite casting, and an internal sleeve allows it to have a limited axial movement, thus enabling it to follow the movements of the belt. The body rotates on ball bearings around the sleeve, and labyrinth seals are adopted to exclude foreign matter. Bearings are packed with grease before dispatch and a grease nipple is provided at the top of the Guidler for subsequent lubrication. Standard brackets of the type shown in the illustration are available. The makers advise that the pulleys should be mounted near and previous to the support rollers, as it is at this point that the vertical oscillation of the belt is at the minimum. Four types are available for different belt thicknesses, ranging from 0·25 to 0·75 in. They can be used equally well with rubber or woven-wire belts.

★ ★ ★

PNEUMATIC VIBRATOR FOR FOUNDRY CORE BOXES

The recovery of cores by hand on the foundry floor, unless carefully carried out by skilled personnel, may be attended with such risks as split or broken core-box cleats, while hammer or mallet blows delivered in haphazard fashion on the box are likely to lead to damaged cores, thus increasing trowelling time. Moreover,



Pneumatic vibrator for freeing cores from foundry core boxes. The air clamp is adjustable between 3 in. and 7 in., and grips a cleat on the inverted core box. Orbital vibrations at the rate of 9,000 a minute are capable of freeing cores weighing up to 3,000 lb. in less than 90 seconds.

deeply-ribbed cores often present difficulties in obtaining a clean recovery.

To assist the foundryman in these circumstances, the Consolidated Pneumatic Tool Company, Limited, 232 Dawes-road, London, S.W.6, have introduced a pneumatically-operated core-box vibrator capable of producing 9,000 orbital vibrations per minute. The unit, which is shown above, weighs 34 lb. and is clamped on to a cleat of the inverted core box. The air-clamp jaw grips are adjustable between 3 in. and 7 in., and do not damage the cleats nor does the vibratory action weaken the core boxes. It is claimed that cores weighing up to 3,000 lb. are freed in less than 90 seconds, and that it is

Inclined guide rollers mounted at the sides of conveyor belts can save the edges from damage and stop existing damage from becoming worse.

only necessary to place the vibrator in position on the box once.

The makers emphasise that all cores are drawn clean regardless of their size or complexity, and that long vertical edges do not cave in or thin sections distort or fracture. It is pointed out that trowelling time is eliminated, that operator fatigue is reduced, and that cores remain dimensionally accurate because core boxes do not go out of square as a result of repeated hammering.

★ ★ ★

TRACTOR EXPECTATIONS

On almost any industrial site, particularly where any amount of earth moving is involved, will be found a tractor. The type may vary, but whatever it is, it will be working up to its limit. To know what those limits are, the British Standards Institution has produced Specification No. 2800 : 1957, which is entitled " Tests for Industrial Crawler and Wheel Tractors."

The standard provides a series of test conditions both for the engine and for the tractor as a whole, and lays out test report forms into which the results can be entered. Such results should be available from all manufacturers and should therefore give to the purchaser a complete guide as to what his tractor is capable of doing, at least, when it is tried out in the ideal conditions laid down in the test procedure. What, of course, it will actually do on the site, he will find out for himself.

One note in the foreword of the standard states that it does not cover agricultural tractors, and also that the appropriate standard for them does not provide for tests designed to investigate their suitability on severe gradients. In view of some of the land that is now being brought into agricultural use, it would seem that this test might very well be added to the specification.

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ELECTRIC GENERATORS FOR DELHI

The rapid industrial and commercial development in Delhi has resulted in a shortage of electrical power in the city. To overcome this, hydro-electric development is taking place. But while the necessary works are being constructed, the Delhi State Electricity Board has ordered British Diesel generating sets with a total output of more than 20 MW to meet the situation. The plant will increase the existing installed capacity by about 20 per cent. and will enable the restrictions in supply, which have been imposed on certain new buildings, to be removed.

The sets supplied for this purpose are of two types. The first consists of 12 cylinder V-form pressure-charged engines (with a site rating of 2,972 b.h.p. when running at 428 r.p.m.) which are coupled to 2,140 kW, 11 kV three-phase 50 cycle alternators. The other is made up of six-cylinder pressure-charged engines (with a site rating of 1,440 b.h.p. at 428 r.p.m.) which are coupled to 1,012 kW, 11 kV three-phase 50 cycle machines. In both cases the engines were manufactured by Mirrlees, Bickerton and Day, Limited, Stockport, and the alternators by the Brush Electrical Engineering Company, Limited, Loughborough.

It is intended that some of the larger sets shall be used to replace existing machines in the present station in the centre of the old city; while others, together with a number of the smaller sets, will be installed in a new station at Kilokri on the eastern side. The remaining 1,012 kW sets will be added to the central steam power station at Rajghat, where their output will be supplied to the existing bus bars.

It is worthy of notice that although the order for the first of these sets was only placed in November, 1956, they have already been delivered in Delhi in spite of the shipping difficulties caused by the closing of the Suez Canal.

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EARTH-BORING MOLE

An air-powered " mole," designed for pushing a way through embankments for electric cables or for similar applications, has been developed in Poland and is shown in the illustration. The mole is driven forward by the action of an internal piston which is repeatedly hammered against the inside of the cylinder head by an intermittent compressed-air supply of 60 to 90 lb. per sq. in. The rate of travel is said to be between 65 and 130 ft. per hour depending on the nature of the soil. It is claimed that the mole can be controlled to take either a straight or curved path.

The mole is 3 ft. long, 3½ in. in outside diameter and weighs 53 lb. The piston which drives it weighs 14½ lb., is 2·8 in. in diameter and has a stroke of 6 in. The first public demonstration was at the recent Poznan Fair where the photograph used in the illustration was taken. Commercial inquiries in respect of the mole should be addressed to Centromor, Motokowska 49, Warsaw; its inventor is Mr. Wiktor Zinkiewicz.

An intermittent supply of compressed air at 60 to 90 lb. per sq. in. is used to drive this mole through embankments.

A TIMBER SHELL-ROOF

LOW-COST MODERN INDUSTRIAL BUILDING

A unique timber shell roof—combining the most recent of structural conceptions with the cheapness of simple carpentry—has just been completed for an extension building for the Royal Wilton Carpet Company at their factory near Salisbury. The single-storey building, which will have a clear floor area of 10,300 sq. ft., is the work of Mr. Robert Townsend, F.R.I.B.A., of Bath, and forms an excellent example of modern industrial building in an advanced architectural style. It is sited close to 300-year-old buildings which are still in use but, despite the striking contrast in styles, the result is pleasing to the eye.

The advantage of shell roof construction is the economy of material effected. A shell roof consists of a thin sheet so curved that it supports all the loads distributed over its surface by direct stresses only, as does an arch; given a suitable curvature, the stresses are uniform and, ideally, the maximum that the material can withstand. This is in contrast to beams which support their loads by a bending action where only the skin stress can be equal to the maximum permitted and where the stress changes from compression to tension within the depth of the beam, being necessarily zero at the neutral axis.

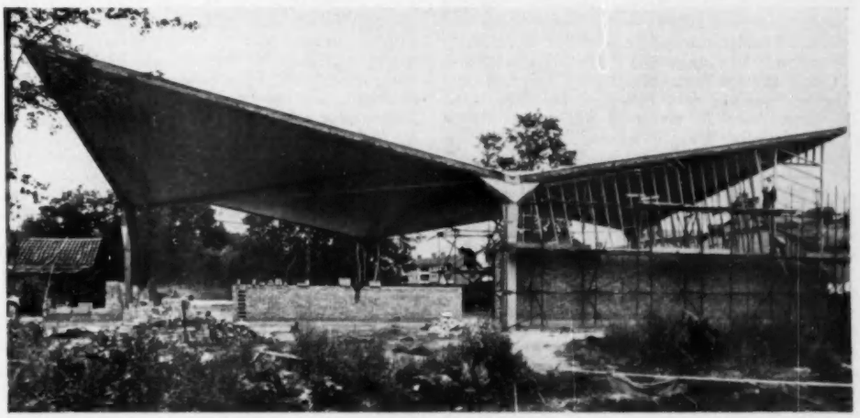
This attribute of shells has been exploited for some years now, notable in the form of simple barrel roofs, either of reinforced or prestressed concrete. The choice of a barrel, or cylindrical, form has been dictated primarily by the need to simplify construction and the framework required is relatively simple to set up. Other curved surfaces, however, are more exciting architectural solutions to roofing problems and some, particularly those related to the conic sections—the paraboloids—are capable of rigid stress analysis when subjected to uniformly distributed loads. These surfaces derived from the conics possess, as many of our readers will be aware, the characteristic that a straight line can be drawn across the surface through every point on the surface; it is this fact that makes such curved surfaces a practical constructional problem.

Hitherto shell roofs have almost without exception been built of reinforced concrete. Due, however, to the efforts of the Timber Development Association, the problems of constructing these roofs in timber have been largely resolved and one has now been completed for Royal Wilton's new workshop. The roof, which is shown in the accompanying illustration, is described as a multiple hyperbolic paraboloid structure (a hyperbolic paraboloid is most readily imagined by considering a flat rectangular plate—in this particular case, a square plate—with the two diagonally opposed corners raised while the edges are kept straight). The design of the roof is principally the work of Dr. H. Tottenham, A.M.I.C.E., of the T.D.A., and prior to construction a quarter-scale model was built at their research station at Tylers Green, near Beaconsfield, where it successfully withstood the expected loading. The advantages of timber, *vis-à-vis* concrete, for shell roofs, are two-fold. For the minimum thickness of shell which it is practicable to construct, the mean stresses are so low that a poor-quality wood is adequate for the shell boarding. Secondly, although a supporting gantry is required to support the shell during construction (as for reinforced concrete) no shuttering is required; moreover, there is no problem of keeping the reinforcement in position. At Wilton the roof consists of four such "plates," each 57 ft. 5 in. square, side by side to form a square with sides of 114 ft. 10 in. The whole roof is carried on only four columns, at the mid points of the sides; that is to say, at opposing corners of the elementary squares. The effect of loading the surfaces—including the uniform self-weight of the roof—is to put the restraining edge beams into compression and an equivalent additional tension into the ties which lie along the diagonals between the supporting columns.

The building is completed by a non-bearing wall reaching up to the roof level and consisting, at the bottom, of a brick and concrete-block cavity wall which is surmounted by glazing throughout the full perimeter except for small timber "cornerings." The mullions for the windows are normal to the roof line, so emphasising the styling of the building. The free floor area is 110 ft. square and the headroom varies from 18 ft. at the stanchions to 30 ft. at the columns. The roof itself is 114 ft. 10 in. square in plan and the shells are only $1\frac{7}{8}$ in. thick, comprising three layers of $\frac{5}{8}$ in. by 5 in. wide tongued-and-grooved European redwood of fifth quality, the top and bottom layers running parallel to the sides (though at right-angles to each other) and the middle layer laid along a diagonal. Thus the top and bottom layers are sensibly straight while every run of boarding in the middle layer is parabolic. The lower and middle layers are bostiched together, and the top is held down by $1\frac{1}{2}$ in. long 12 s.w.g. wire nails. A 6 ft. wide strip round the perimeter of each "plate" is glued with Aerolite 300 urea adhesive in addition to the nailing.

The edge beams are of laminated construction, made from 1 in. by 10 in. wide unsorted redwood boards glued with Cascophen. The beams are 12 in. deep and 58 ft. $8\frac{1}{2}$ in. long, with a twist of 12 deg. along their lengths to accommodate the curvature of the shell. They were pre-formed on the ground and twisted during fabrication; when in position the shell boarding is fixed at the mid-depth of the beams.

To erect each of the four sections of the roof tubular scaffolding was built up to the underside of the shell, with straight tubes running parallel to the edges and rising with the surface. The edge beams were supported in position, and the lower layer of the shell boarding laid on the scaffolding; the middle and top layers were then added in turn and fixed in position. Two coats of a p.v.a. glaze have been sprayed on to the underside of the roof and the top weather side has been covered with two layers of Ruberoid, the bottom one being random nailed and the top layer stuck down with bituminous adhesive and dressed off with a fine sand. To hold the roof down against a wind load acting on the underside, particularly during construction, four guy lines have been fixed just outside the building line and near to the flying corners of the building. These guys will be permanent for it is not intended to fasten the roof down to the walls, but to leave a working gap at the top of the wall which will allow for deflections under load.



An attractive modern workshop for the Royal Wilton Carpet Company is being erected with a multiple-leaf timber shell roof. Only four columns are required to support the roof which covers a clear working area of 10,300 sq. ft.

Work began on the site on February 25 of this year and the building is expected to be completed by the end of July. Without lighting and heating, the estimated cost of the building is less than 28*s.* per sq. ft., or about half the normal cost for this size of floor area. Labour for the walls and the carpentry for the roof will be charged to the net cost as no contractors were employed, though the concrete floor, the four concrete columns and the scaffolding were sub-contracted. The total cost of the roof including the scaffolding and everything above the column heads—the edge beams, the shell boarding, the rods and the Ruberoid—works out at less than 10*s.* per sq. ft.

LIMITATIONS IN CONCRETE

Bond and Crack Formation

The early history of reinforced concrete is not well known and it seems that the first use of steel was merely intended as a supporting network. However, in 1854, a patent was issued to a Newcastle plasterer, W. B. Wilkinson, for reinforcing concrete tensile zones with flat bars and second-hand wire ropes and it would seem that he was to some extent aware of the principles of reinforced concrete as we know it to-day, formally established by Monier (1867) and Wayss (1886).

The early work in reinforced concrete had to employ materials of rather low quality and as late as 1920 permissible steel stresses were, in general, below 12,000 lb. per sq. in for mild steel with a yield of about 36,000 lb. per sq. in. Since 1925 development, particularly on the continent, has been toward the use of high-tensile steels with working stresses being continually raised until stresses of 35,000 lb. per sq. in. may be used in some cases. Since the manufacture of high-grade steel increases the cost of production, various attempts have been made to find alternative ways of increasing the yield point. Recently, cold working in torsion has been extensively adopted with considerable success.

The use of higher permissible steel stresses involves an increase in the width of cracks due to the larger steel strains. To improve bond and to help to give a better distribution of cracking the use of uneven surfaces on the reinforcement has been employed for some time. In America,

the deformed bar arrived before the use of high-tensile steel. The purpose of the deformations raised on the bars is to provide a mechanical bond quite apart from the normal bond due to the glueing effect and friction effect. Opinions concerning the advantages of the various types of deformation in use are still much divided.

The development of engineering techniques is largely influenced by economic considerations and advantages in cost are always being sought. The use of higher steel stresses, with the consequent savings in materials, is an obvious way of reducing costs but it may only be adopted if it leads to satisfactory results. It was to promote an exchange of ideas and experience on these problems and to stimulate further research that a symposium on bond and crack formation in reinforced concrete was recently held in Stockholm; the symposium was organised by the Swedish Cement and Concrete Association and was held under the auspices of the R.I.L.E.M. (Réunion Internationale des Laboratoires d'Essais sur les Materials et les Constructions.) The symposium was attended by about 160 delegates from 26 countries and most of the internationally known figures in reinforced-concrete research were present. Two thick volumes and a number of pamphlets containing some 50 papers were contributed so that the three days of meetings did not give an adequate opportunity to compare contributions and much work will have to be done after the symposium.

Nevertheless, one of the most significant conclusions reached concerned the corrosion of reinforcement. It now seems to be well established that the commonly accepted maximum crack width of 1/100 in. never causes trouble in normal environments and in general corrosion is very rarely due to loading cracks. Almost all cases of corrosion can be traced to poor quality concrete, reduced cover or cracking due to bad detailing for temperature and shrinkage movement.

In 1952 the Cement and Concrete Association organised a symposium on "Concrete Shell Roof Construction" which was held in London. As a result of this the Norwegian Society of Engineers and the Norwegian Concrete Association considered it useful to hold a second symposium on a more international basis. For this three-day meeting some 200 delegates registered from 25 countries. The programme consisted of invited papers intended to give a picture of the progress of shell construction and the development of theory, design and research during the last five years.

SHELL ROOFS

In the field of construction many examples were shown of ways of reducing the cost of shells, mainly by partially or totally eliminating the shuttering and scaffolding required for in-situ construction. These methods consist of part or total pre-casting in sections, casting the complete roof structure on the ground and lifting it into position and the use of self-supporting tubular networks buried in lightweight concrete on permanent shuttering in the form of expanded metal. In some special cases reinforced brick has been used with success and an example of a timber shell is the subject of the article on the previous page. Pre-tensioning of the shell is frequently very useful to improve the edge conditions, to assure the impermeability of the concrete and thereby avoiding the danger of cracking. There is now good evidence for the claim that shell construction can be truly competitive with other forms of roof construction.

For practical design a large body of the tabulated data has become available to reduce the labour of applying the well-established eight-order differential equation methods. In this way shell design has been reduced to the proportion of that of ordinary statically indeterminate structures. At the first shell symposium there was little evidence that much progress had been made with what were then called the "unsolved" problems, such as longitudinal continuity, non-circular cross-sections and variable thickness. One of the main features of the present symposium and other recent publications, has been the presentation of a number of different approaches to render these problems amenable to logical design. The next few years should establish the value of some of these approaches in practical design office use. Tabulation of new data for design use, the exact solution of more complicated structures, and, indeed, the complete analysis of shells may often be carried out more economically by the use of electronic digital computers, which have recently become available for civil engineering calculations.

Except for certain general considerations, shells with double curvature were not treated at the first symposium. The present symposium has shown that meanwhile considerable progress has been made in the computation of the state of stress and deformation of this type of shell. A number of approximations were explained which can be used to simplify calculations for these shells. It has been shown that even north-lights can successfully be built by using shells of double curvature.

The absence of presented papers on limit analysis seems to indicate that there has been little recent development in this field. In the discussion, some account was given of an attempt to develop an ultimate load analysis from the fundamental theory of plasticity rather than an empirical approach, but it was indicated that these studies are very complex and an adequate treatment of shells may not be available for some time.

It has been suggested that there is no clear evidence of any practical cylindrical shell having suffered distress or collapse by buckling. Although the problem may not yet have become of primary practical importance, it may become very real as the size of shells increase. A number of contributions on this subject have been presented, but they all deal with rather restricted aspects of the problem. There is obviously a great need for a general theory of stability backed up by adequtae experimental evidence. Many of the valuable accounts of model tests presented at this symposium will be useful in this respect.

Many proposals were shown in which new forms of shell, with great aesthetic value, were employed. In the case of these shells of special and unconventional shapes it is always possible to find the conditions of strength and stability of the design by experimental analysis methods, especially on reduced-scale models. It was agreed that more work should be encouraged in this field.

There can be no doubt that the symposium was highly successful and arrangements were made to organise a further meeting in three to four years time.

OPEN-CAST IRON-ORE MINING

World's Largest Walking Dragline Used for Stripping Overburden

A machine which will depreciate at about £10 for each hour of every day in its early working life has been brought into use by the ore-mining division of United Steels Company, Limited, at their Stamford site. It is a Ransomes and Rapier W1400 walking dragline; its capital cost is around £800,000 and in return it will hourly shift up to 1,800 tons of limestone overburden from above a valuable seam of ironstone. Some other and smaller machines will be used to handle the ore itself which United Steels are going to raise at a rate of 2,000 tons a week. This is equivalent to one million tons a year and the outcrop is expected to last about 25 to 30 years—the probable working life of the W1400. With an iron content of about 30 per cent., the Stamford deposit will make a valuable contribution to an expanding steel industry.

The ironstone seam, which is at Exton Park, near Stamford, lies below 20 to 90 ft. of limestone and covers an area of 3,000 acres. The W1400, working 24 hours a day, seven days a week, will be used (after the top soil has been separated) to strip and stack the limestone, piling it beside the open cut. The smaller machines—conventional excavators on crawler tracks—working only five shifts a week, will load away the ore into transport, after which the cut will be backfilled and the top soil replaced, double de-stoned, drained as necessary and returned to agriculture, to be fit for grazing within a couple of years. The ore will go by train to the ironworks of the Appleby-Frodingham Steel Company at Scunthorpe.

The W1400—it is shown in the accompanying illustrations—is the second such machine that Ransomes and Rapier have built. (The first, completed about six years go, is used by Stewarts and Lloyds on their Corby site and they have now two more on order; the normal delivery time is about four years, including the 18 months or so erection period on site.) It is an all-British

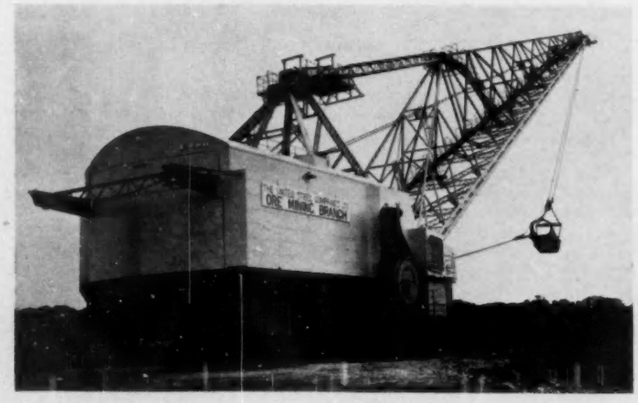


Fig. 1 (left) The world's largest drag-line, a Ransomes and Rapier W1400, has begun work stripping overburden at an open-cast ironstone quarry belonging to the United Steels Company.

Fig. 2 (right) With a 282 ft. long boom and a 20 cub. yd. bucket, the W1400 can shift more than its own weight——1,675 tons—in an hour. Its maximum depth of reach is 100 ft. and it is as long as a football pitch.

machine designed by Mr. J. M. Cameron of Ransomes and Rapier, Limited, and built at their Ipswich works.

With a 282 ft. long tubular steel jib and its peculiar method of shuffling backwards—it always travels with the boom pointing behind itself—the W1400 is claimed to be the largest walking dragline in the world. It weighs 1,675 tons and throws a 20 cub. yard bucket which itself weighs 22 tons and—as one of the illustrations shows—will easily accommodate a family saloon car. It is all-electric, collecting power from the mains at 6,000 volts alternating current through a trailing cable to feed two 1,500 h.p. motor-generator sets which, in turn, supply the 14 main driving motors, each of 225 h.p. The whole of the superstructure house is pressurised, using air filtering and fan equipment. This air pressure serves the dual purpose of ensuring ample cool air for the electrical equipment and of preventing the entry of dust.

When digging and slewing, the machine is carried on a 48 ft. diameter steel drum which reduces the mean bearing pressure down to about 1 ton per sq. ft. Around the upper perimeter of the drum is the main roller path carrying a live ring of 120 tapered rollers and supporting the whole of the rotating superstructure. In order to " walk ", the boom is slewed round to a direction opposite to that in which the machine is about to advance and the weight is then taken principally by the two walking shoes, each 48 ft. long by 9 ft. 6 in. wide, fitted to legs slung from eccentrics, one on each side of the machine. As the eccentrics revolve, the weight of the machine is transferred to the shoes but the weight of the jib causes the trailing edge of the drum to retain contact with the ground, ensuring the positive balance and safe three-point support of the machine. As the eccentrics continue to revolve the machine drags itself backwards, taking a " step " of 6 ft. 10½ in. With the completion of the step the shoes rise clear of the ground and the weight of the machine is again taken by the drum. Safe operation of the machine requires a sensibly uniform standing surface, though the shoes are fitted to the legs by ball and socket joints so that some uneveness can be taken up; a falling incline can be negotiated when the machine advances but there is a sharp limit to rising path which the machine can climb. The standing surface should also be of a fairly uniform texture, otherwise the drum is liable to be punctured.

Some idea of the spaciousness of the motor room is given by considering the tail radius of 68 ft. 6 in. and the width of 49 ft.; the 25 ton E.O.T. crane which is used for servicing the motor room confirms the impression. The great jib is of all-tubular welded construction, triangular in section. In normal working order the jib is connected to the A-frame by a tubular suspension member, but it can be lowered to the ground by using the jib-hoisting winch. The drag and hoisting machinery consist of two complete winding units, each driven by four main motors through balanced gear reductions; Ward Leonard amplidyne control is used so no operating brakes or clutches are required, though electromagnetic parking brakes are fitted on each motor. The maximum pull on each winding barrel is 100 tons and rope speeds range from 290 ft. per minute at normal full load to 513 ft. per minute at no load. The rotating speed is 1¼ revolutions per minute—which gives the jib head a speed of nearly 23 m.p.h. Thus the machine has a working cycle of about one minute to dig, slew, dump and return; at each bite it grabs 30 tons to give it a full working capacity of 1,800 tons of spoil an hour shifted from a depth of 100 ft. below and 260 ft. in front of itself to a point as much as 260 ft. behind itself and up to 120 ft. above standing ground level.

SUPERSONIC WEAPONS SYSTEM

The P.1 Single-Seat Fighter

Concurrently with the announcement that the first of the " development batch " of P.1B single-seat all-weather fighter aircraft, powered by two Rolls-Royce Avon engines, has flown, in the course of normal development work, at speeds higher than the present official world speed record (Mach 1·73), the aircraft division of the English Electric Company, Limited, Warton, Lancashire, have recently given to the Press an impressive display of the P.1 aircraft's controllability when manoeuvring at very high accelerations—the supersonic capabilities, naturally, could not be demonstrated at low altitude!

The aircraft flown, and shown in the accompanying illustration, was in fact the first of the two experimental twin-Sapphire-powered P.1 machines. (The other P.1A is now centred at the Royal Aircraft Establishment, Bedford.) This aircraft is currently concerned primarily with development work to " stretch " the subsonic cruising performance. To this end, the leading edge of the outer wing has been given an increased camber to improve the airflow over the wing tips at high incidence: it has still to be determined whether this modification will have an adverse effect on supersonic drag characteristics, which in the original wing—and as fitted on the military pre-production P.1B—have surpassed the expectations of the aircraft's designers.

The P.1 project was initiated in 1950 to a Ministry of Supply specification for a research aeroplane, but was designed from the outset for development into a fully operational aircraft. It represents a big step forward in design, from the transonic fighter aircraft such as the Hunter to the well-and-truly supersonic integrated " weapons system." It is for this reason that, seven years after conception, it is still far from delivery to the Royal Air Force, although many service pilots both from the experimental establishments, and from Fighter Command, have now flown the P.1; and for this reason that 20 pre-production machines are on order—the first, as already indicated, is flying—for proving the combat capabilities of the aircraft in all its aspects.

The first P.1A aircraft, now engaged on development work to improve cruising performance, has a modified leading edge giving increased camber at the wing tips.

Perhaps the term " weapons system " requires some explanation: whereas the pre-supersonic aircraft has generally been designed as an airframe with stowage space for armament and other operational equipment, in modern American combat aircraft and in the English Electric P.1, the radar fire-control system, the various flying aids, and the guided missiles that the aircraft will carry have all been developed concurrently, under the co-ordinating influence of the aircraft contractor, as a complete system " tailored " to the performance of the aircraft.

It is interesting to compare the genesis of Britain's two supersonic aeroplanes. The record-holding research aircraft, Fairey F.D.2, by the happily inspired guesses of its design team, took successfully to the air with a very meagre background of wind-tunnel experiment. In contrast, extensive wind-tunnel investigations were carried out by the English Electric Company before the aerodynamic design of the P.1 was finalised; the data from these tests, backed up by knowledge derived from American and overseas investigations, led to the adoption of the 60 deg. swept-back wing and the low-set tailplane, which is placed well below the main wing to avoid the tail-down pitching moments that are likely to beset high-speed aeroplanes at subsonic speeds when the tailplane is fixed high on the fin. As a result of these preliminary researches, the prototype aircraft have experienced no major aerodynamic troubles during their aerodynamic proving trials—now nearly complete—and only the air brakes have called for any redesign; as already noted, the low supersonic drag of the wing has delighted the design team. The slow-speed handling characteristics and the high rate of climb of the aircraft are also said by the test pilots to be excellent.

The actual performance of the P.1 has not been disclosed. Although there is " some titanium " in the structure, it would seem that aluminium alloy is still the main structural material and it seems probable that the aircraft is not designed to surpass Mach 2. Improvements in performance are likely to be directed mainly to stretching the climb, range and load-carrying capabilities rather than the top speed, which would involve a major redesign of the structure. Refrigeration is, naturally, provided for the pilot and the electronic instruments.

The makers claim that the engine layout has several advantages. By setting one engine in front of, and rather below, the other, the aircraft has the thrust of two engines for the frontal area of appreciably less than two. Moreover, should one engine fail, no asymmetric thrust problems arise; whereas with a larger single engine the pilot would probably prefer to bale out rather than attempt a glide approach if the engine failed, in the P.1 the pilot stands an excellent chance of returning safely to base with one engine out of action. The P.1 can maintain supersonic speed on two engines without reheat. Also, the two engines allow a complete duplication of all the essential services in the aircraft.

To ease the task of the operational pilot and allow him to concentrate on interception rather than flying, it is likely that the production aircraft will be fitted with electronically-controlled autostabilisers. The manufacturers emphasise, however, that the aircraft has been designed to be aerodynamically stable, and that up to the present all development flying has been carried out without autostabilisation. Thus, in the event of failure of the " little black boxes," there will be no vicious characteristics for the pilot to contend with. Other features to aid the pilot include the installation of specially-developed flight instruments such as the roller-blind attitude indicator which replaces the artificial horizon and is not subject to topple at high angles of climb. An instrument of this type was described on page 373 of the September 21, 1956, issue of ENGINEERING.

The servicing requirements of a complex aircraft like the modern supersonic fighter are inevitably formidable, and to cope with them, the English Electric team have in hand designs for a mobile hangar containing all the necessary hydraulic, electrical and lifting facilities.

ATOMIC REVIEW

Mosaic

THERE is no plot this week. Just a series of general notes. They have been brought together in recent weeks as a result of the attention that has been given to portraying specific aspects of atomic energy. But the mosaic has its place in the composite picture of nuclear development. It is the random distribution that shows the infinite variety.

Reactors at Het Atoom

A new scale model of the General Electric Company's design of an atomic power station is being shown for the first time in Amsterdam at the "Het Atoom" exhibition, which opened on June 28. The model represents part of the station which is to be built for the South of Scotland Electricity Board, and is on display on the Board of Trade stand together with exhibits from the United Kingdom Atomic Energy Authority. Built to a scale of $\frac{1}{48}$ in. to 1 ft., it shows the two 200 ft. high reactor buildings and the turbine hall, one reactor and part of the turbine hall being sectioned to reveal details of construction and operation. Details of the stations were given in Atomic Review last December 21, February 8 and February 15. The exhibition is open until September 15.

A cut-away model of the type of nuclear power station to be designed and constructed by the Anglo-American team of Mitchell Engineering Limited and A.M.F. Atomics Incorporated, for the Rheinisch-Westfalische Elektrizitat (West Germany) will be one of the features at the Het Atoom exhibition. A.M.F.-Mitchell offer power plants using the closed-circuit boiling-water reactor and were recently awarded a contract to build West Germany's first nuclear power station. The model on view represents a power station of 20 MW electrical capacity and is open at one side to show the interior of the reactor building and the turbine house. The reactor vessel is also cut away to show the core and control-rod mechanism. Four heat exchangers serve the reactor. The reactor house is shown above ground level but in actual construction it may be built underground. This will be the case with the power plant in West Germany. The reactor core consists of numbers of fuel assemblies containing fissionable fertile material—uranium and thorium—in oxide form. Details of the A.M.F.-Mitchell project were given in Atomic Review on March 29 and April 5.

Another A.M.F. exhibit is a 10 kW swimming pool type research reactor. This was the first nuclear reactor designed and built in the United States for a foreign country under President Eisenhower's "Atoms for Peace Programme." The reactor, which became critical at the end of last month, was constructed in co-operation with Dutch industrial organisations and operates with 20 per cent. enriched uranium fuel supplied from the United States. Only a few grammes of uranium 235 are required to obtain the reactor's daily energy output. When the exhibition closes on September 16, the reactor will be dismantled and taken to a Dutch technical university where it will be reassembled and integrated into a complete nuclear research centre. The reactor will then be operated at ten times the power at which it will operate at the exhibition.

Heaviest Element

A new element has been created in Stockholm. In neglect of current publicity techniques its vital statistics—atomic number, 102; half-life, 10 minutes; emits 8·5 MeV alpha particles—have been announced before its name has been fixed.

Swedish, American, and British scientists co-operated in the project. The new element was made by bombarding curium-244 with ions of carbon-13. The 225 cm. cyclotron at the Nobel Institute accelerated the ions. The Argonne National Laboratory supplied the curium, having separated it from spent reactor fuel. Harwell supplied the carbon. Total production of element 102 amounts to several micrograms.

Element 102 is the first artificial element to be discovered in Europe; the others were found in the U.S. The latest results are interesting in their demonstration of the value of using heavy nuclei in the bombardment of atoms. It is hoped that future accelerators will accelerate even heavier nuclei so that further elements can be produced. One difficulty with such elements is that they are increasingly unstable as their atomic weight increases. However, it is possible that certain stable isotopes exist.

The target material that was bombarded in the cyclotron was in the form of a thin film of curium on an aluminium foil, placed in a specially fabricated probe so that the recoils from the nuclear reactions could be caught on clean foils and identified rapidly. For the best results, thin organic foils were used as catchers for the recoil atoms. These foils were dissolved in a drop of acetone on a platinum plate, which was flamed to give a thin source for pulse analysis. The platinum plate was treated with hydrochloric acid to put the activity in solution which was passed through a standardised ion exchange column. Alpha-hydroxyisobutyric acid was used to extract the new element from the column.

Aircraft Firm Facility

A U.S.A.E.C. permit for the construction of a critical assembly facility at Palo Alto, California, was issued to Lockheed Aircraft Corporation on March 14. The facility, which is scheduled for completion by September 30 at the latest, will be built on a 22 acre site leased from Stanford University, about 2 miles south-east of the University Campus. Because of the earthquake history of this area of California, the structure will be built to the Californian Code, which requires that it should be able to withstand 0·2g lateral acceleration. The assembly building will be an underground reinforced-concrete structure, 40 ft. from the nearest building (in which the control room is situated), comprising the 45 ft. by 25 ft. by 15 ft. assembly hall (17 ft. underground), with an entrance tunnel and two small service and storage rooms. The critical assembly will be enclosed in a steel pressure vessel (capable of withstanding 200 lb. per sq. in.), 7 ft. in diameter and 11½ ft. long.

Several experiments are proposed using enriched uranium as fuel and beryllium as both moderator and reflector, studies of the critical mass with varying core composition and of temperature coefficients of reactivity up to 500 deg. C. being of particular interest. In one type of assembly the core will consist of fully enriched uranium metal foil interspersed between layers of beryllium metal, reflected on all sides by 2 in. beryllium. Critical assemblies will be performed by loading fuel to a pre-chosen dimension into the two separated halves of the assembly. The pressure tank will then be closed, the assembly room sealed off, and the two halves brought together by remote control to form a right cylinder of approximately 12 in. diameter and of variable height.

Fuel-type safety, shim and control rods (one of each) will occupy a vertical channel along the axis of the fuel and moderator cylinder, the control and shim rods being inserted from below and the safety rod from above. The shim and safety rods, 5 in. diameter and 12 in. long with a 1·75 in. axial hole to accommodate the control rod, each extend only halfway through the assembly and share the same channel. The control rod, 1·75 in. diameter and 24 in. long, extends through the assembly coaxial with and inside the shim and safety rods. Thus, on the insertion of all three rods, a solid structure of fuel and moderator is formed. Complete withdrawal of all rods leaves a 5 in. axial hole in the assembly and removes about 2½ per cent. reactivity. Automatic devices will ensure that the rods are withdrawn in case of failure.

Electron Radiation Facility

An electron radiation facility, established to encourage ionising-radiation applications for research and industrial processing was recently opened in Cologne, Germany, by Leybold-Hochvakuum Anlagen, G.m.b.H., and High Voltage Engineering Corporation of Burlington, Massachusetts, U.S.A. Incorporating a two million volt, 0·5 kW Van de Graaff electron accelerator, this radiation centre is said to be the first in Western Europe made available on a commercial basis to industrial concerns for experimental and limited production programmes. The radiation source was supplied by High Voltage, and the facility will be managed and operated under the direction of Leybold, which represents High Voltage in Western Germany, Switzerland and Spain.

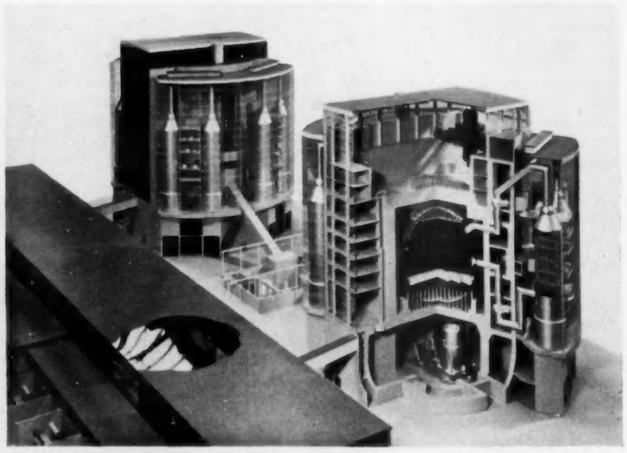


Fig. 1 Scale model of the 300 MW nuclear power station to be built by the G.E.C.—Simon-Carves Atomic Energy Group for the South of Scotland Electricity Board. The two reactors will be of gas-cooled graphite-moderated design.

Tubes for Nuclear Energy

Tube Investments Limited announce the formation of a new subsidiary company, TI Nuclear Engineering Limited, with head office at The Adelphi, London, W.C.2, to assist its operating companies which are concerned with activities in the atomic energy industry in the promotion of business at home and abroad. The following are among the products being supplied to the industry by TI companies: components in reactor-grade materials (fuel element cans and sheaths, and applications of the rare metals for structural purposes); reactor components neutron starter tubes, burst-slug detector gear components, control rods, control-rod stand pipes, charging and discharging tubes, core restraints, absorber rods, fuel-element supports, and reactor tie bars); and also steel tubes, heat-exchanger components, stainless-steel tubing, coils, pressure vessels, aluminium components, electrical switchgear, and rolling mills for nuclear metals. The new company, in association with the Tube Investments Research Laboratories at Cambridge and its Technological Centre at Wallsall, also offers sponsored research and design work, and radiation facilities to outside organisations.

Tube Investments Limited have also published

a brochure giving details of their activities in supplying components and equipment for the atomic energy industry. It includes a new list of engineering and manipulated components; data on the production and testing of zirconium tubes in reactors; techniques for joining beryllium; details of niobium fuel element sheaths; and information on the development of techniques for producing beryllium fuel-can tubes.

A contract worth nearly £¾ million has been received by the Tube Investments subsidiary, Talbot Stead Tube Company, Limited, Walsall, from C. A. Parsons and Company, Limited, Newcastle-upon-Tyne (a member of the Nuclear Power Plant Company Limited), for reactor components for the Bradwell Nuclear Power Station in Essex. The order includes fuel-element support assemblies, charging standpipes, neutron-source assemblies, absorber rods, short charge plugs, control rods, and control-rod standpipe plug assemblies.

Radiation Standards

A new determination has been made of the emission rate of the primary standard photoneutron source of the United States. An absolute calibration method was developed which confirmed the emission rate previously established for the standard, and enabled the accurcy of measurement to be increased.

The primary photoneutron standard is a radium-gamma-beryllium source that produces neutrons by the interaction of gamma rays with beryllium. One curie of radium bromide is contained in a platinum-iridium capsule which is placed at the centre of a beryllium sphere 4 cm. in diameter. Since the capsule absorbs the alpha particles from radium and its decay products, only gamma rays enter the beryllium sphere.

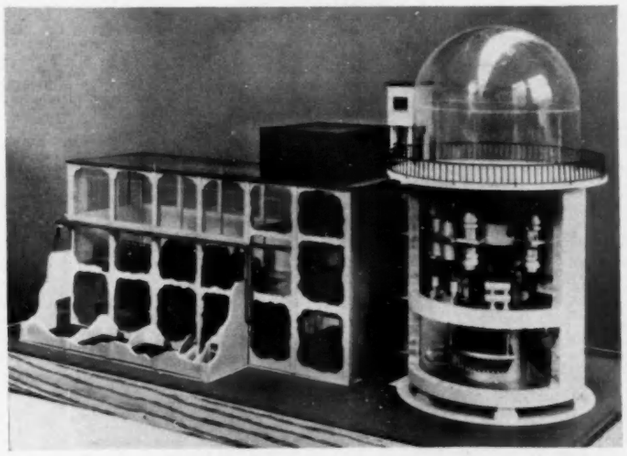


Fig. 2 Model of the Mitchell-A.M.F. 20 MW closed-cycle boiling-water reactor power station. The reactor house is on the right and three of the four heat exchangers can be seen, together with the reactor core and control-rod mechanism. The turbine house is on the left.

The work was carried out by the National Bureau of Standards. Other standards developed have been compared with those of Great Britain, Canada, and Western Germany. The new alpha-particle standard is of polonium-210 deposited on palladium on silver discs. The standard is of great mechanical durability, has no beta component and little or no alpha straggling. Beta and gamma-ray solution standards of hydrogen-3, potassium-42, zinc-65 and tantalum-182 have been added to the list of those produced or released for distribution. To achieve uniformity in X-ray measurements the Bureau has measured the amount of energy required for sulphur-35 beta-rays to produce an ion pair in air. A value of 33·71 ± 0·24 electron volts was obtained.

Pipework at Springfields

A contract for the installation of pipework at the atomic plant at Springfields, near Preston, has been awarded to Mitchell Engineering Limited by the Atomic Energy Authority. Work in this contract falls into several stages and the value of the first stage is estimated at several thousand pounds. The Mitchell company are also engaged on nuclear work at Chapelcross, Capenhurst and Dounreay, and on the nuclear power station for Germany referred to in two previous Atomic Reviews.

Chemical Processing Contracts

The United States Atomic Energy Commission has published the conditions under which it is prepared to contract with operators of private nuclear reactors to provide for chemical processing by the Commission of spent fuel elements from their reactors. Processing costs per kWh for individual reactor operators will vary, depending on such factors as the efficiency with which reactor heat is converted to electricity, the type of fuel element, and the attainable service life or burn-up of the element. (A low burn-up means that the reactor must be shut down and the fuel element removed for reprocessing more often than under conditions of high burn-up.) Principal features of the Commission notice are as follows. 1. Contracts with private reactor operators extending through June 30, 1967, will be negotiated on the basis of operating a conceptual plant, capable of processing all the fuel element types now known to be planned for use in power reactors, at a standard daily processing charge of 15,300 dol. Adjustments may be necessary for other types of fuel elements for which costs are substantially higher or lower, or which require modifications of the assumed plant. (The daily rate is based on costs associated with an assumed plant costing 20,570,000 dol. to construct and with annual operating costs, including amortisation, totalling 4,592,000 dol. It is assumed that the plant would be capable of handling daily 1 ton of natural or slightly enriched uranium, and would operate 300 days annually.) 2. Each contract will provide for firm charges for the service, except that they will be subject to escalation on the basis of an appropriate recognised price index to adjust for changes in costs of labour and materials. 3. Contracts will be subject to cancellation by the Commission, on 12 months' notice, if the Commission finds that fuel-element processing services are available commercially at reasonable prices. 4. The services will provide for the mechanical, metallurgical and chemical treatment of spent fuel elements and blanket materials and storage of resulting wastes. 5. The processing system would yield purified nitrate salts of uranium and plutonium. There will be additional charges (not yet established) for conversion of these products to forms—uranium hexafluoride and plutonium metal—for which Commission prices have been established. There will be an additional standard charge to cover process losses and, unless waived by the Commission, a use charge for the materials during the normal processing time.

Nucleonic Instruments

The fourth edition of the "Isotope Book" published by the Nucleonics Group of the Scientific Instrument Manufacturers' Association is to be issued on July 5. Entitled *British Nucleonic Instruments*, 1957, it is a comprehensive volume of 176 pages listing the sources of supply of all kinds of nucleonic instruments, accessories, and other equipment for the handling and application of radioactive isotopes, for atomic power station instrumentation, and for laboratory, industrial and medical uses of the new isotope techniques. Over 90 firms are represented in the book, most of them listing and illustrating their particular products. A classified buyers' guide section enables the user to make a quick selection of possible sources. Priced at 10*s.* 6*d.* the book is available from SIMA. Sir John Cockcroft, director of the Atomic Energy Research Establishment at Harwell, contributes a foreword to the volume.

Electronic Calculator for Nuclear Research

The first type 555 Electronic Calculator, made by the British Tabulating Machine Company, Limited, is now in use by the Computing Group of the United Kingdom Atomic Energy Authority at Harwell. The machine will be employed almost exclusively for data processing and for computations involving use of the "Monte Carlo" technique. The former concerns the interpretation of measurements made with experimental facilities attached to the research reactors (BEPO, DIDO and others) and to the various high-energy particle accelerators. Nuclear phycisists at Harwell are undertaking very large programmes of measurements of fundamental properties of matter, essential to the proper development of reactor technology, as well as to the understanding of nuclear physics. In all this work a great deal of calculation is needed to obtain from the raw data the information the experiment is designed to produce.

The Monte Carlo mathematical-statistical method for studying physical phenomena in which random processes occur is being employed with the aid of the electronic calculator to trace the life history of neutrons. The first problem posed concerned the leakage of neutrons down channels in a reactor, such as, for example, those carrying cooling ducts. The method involves tracing the life histories of several thousands of neutrons—a sample survey—and using this information to predict the behaviour of the very much larger number of neutrons in the actual reactor. This type of problem, intractable by conventional mathematical methods, because of the huge amount of computation necessary, now becomes capable of solution with the assistance of high-speed electronic calculating machines.

Plutonium Prices

Admiral Lewis L. Strauss, Chairman of the United States Atomic Energy Commission has recently announced prices to be paid by the Commission for plutonium produced in the operation of licensed power and research reactors in the United States between now and June 30, 1963. For purchases between now and July 1, 1962, the price will range from 30 to 45 dols. per gram depending on the plutonium-240 content of the material. For the year July 1, 1962, to June 30, 1963, a single price of 30 dols. per gram will be in effect. These prices supersede all previous guaranteed fair prices for this material and details of the new schedule will be published in the Federal Register. The 1954 Atomic Energy Act authorised the Commission to guarantee prices domestically for a period not to exceed seven years. The prices announced are based on these provisions. The Commission intends to continue the practice of extending annually for one year, the period for which guaranteed prices of plutonium have been established so that the guarantee period will extend at least six years in advance at any one time. In making such extensions, the Commission expects that the guaranteed fair price for plutonium will be reduced, as dictated by consideration of the value of the material for its intended use by the United States and giving such weight to the actual cost of producing it as the Commission finds to be equitable, to a level based upon the fuel value of plutonium in commercial power reactors.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *May* 31, *page* 702; *or June* 28, *page* 830. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Atoms Exhibition.—In August, at Geneva. Address of organising committee: 1 Place du Lac, Geneva, Switzerland. See ENGINEERING, **December 16, 1955, page 816.**

Dornbirn International Export and Trade Fair.—Fri., Aug. 2, to Sun., Aug. 11, at Dornbirn, Austria. Apply to the Export & Mustermesse Gesellschaft m.b.H., Dornbirn, Austria; or to the British-Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

Industrial Engineering Exhibition.—Mon., Aug. 5, to Sat., Aug. 10, at Melbourne. Apply to the Industrial Public Relations Service of Australia, 82 Toorak-road West, South Yarra, Melbourne, Victoria.

Soil Mechanics and Foundation Engineering, International Society of: Fourth International Conference.—Mon., Aug. 12, to Sat., Aug. 24, in London. Apply to the Society's secretary, Mr. A. Banister, Institution of Civil Engineers, Great George-street, London, S.W.1. Tel. WHItehall 4577.

Sydney Motor Show.—Fri., Aug. 16, to Sat., Aug. 24, at the Royal Agricultural Society's Showground, Moore Park, Sydney. Organised by the Chamber of Automotive Industries of New South Wales, 75 William-street, Sydney.

Izmir International Trade Fair.—Tues., Aug. 20, to Fri., Sept. 20, at Izmir. Information from the British Chamber of Commerce of Turkey, Piyasa Han 602/606, Asirefendi Cad. 11/13, Istanbul, Turkey.

"Model Engineer" Exhibition.—Wed., Aug. 21, to Sat., Aug. 31, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Organised by *The Model Engineer* (Percival Marshall & Co. Ltd.), 19-20 Noel-street, London, W.1. Tel. GERrard 8811.

Pacific National Exhibition.—Wed., Aug., 21, to Mon., Sept. 2, in the Exhibition Park, Vancouver. Apply to Mr. Ben Williams, Exhibition Park, Vancouver, B.C., Canada.

Canadian National Exhibition.—Fri., Aug. 23, to Sat., Sept. 7, in Toronto. *Representative:* Mr. G. H. Ward, British Columbia House, 3 Lower Regent-street, London, S.W.1. Tel. WHItehall 2794.

Motor Industry Eleventh Annual Summer School.—Sat., Aug. 24, to Sat., Aug. 31, at St. Catherine's College, Cambridge. Organised by the Institute of the Motor Industry, 40 Queen's-gate, London, S.W.7. Tel. WEStern 0915.

Gas Chromatography, National Conference.—Wed., Aug. 28, to Fri., Aug. 30, at Michigan State University, East Lansing, Mich., U.S.A. Organised by the Instrument Society of America, 313 Sixth-avenue, Pittsburg 22, Pa., U.S.A.

Radio Show (24th Annual National Radio and Television Exhibition).—Wed., Aug. 28, to Sat., Sept. 7, at Earl's Court, London, S.W.5. Preview for overseas and special guests, Tues., Aug. 27. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

Engineering, Marine, Welding and Nuclear Energy Exhibition.—Thurs., Aug. 29, to Thurs., Sept. 12, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

***International Union of Public Transport, 32nd International Congress.**—Fri., Aug. 30, at Hamburg, Germany. Organised by the Union Internationale des Transports Publics, 18 avenue de la Toison d'Or, Brussels, Belgium.

St. Erik's Fair, 15th International.—Sat., Aug. 31, to Sun., Sept. 15, in Stockholm. Apply to the manager, St. Erik's Fair, Stockholm 28.

Czechoslovak Engineering Exhibition.—Sun., Sept. 1, to Sun., Sept. 22, at Brno, Czechoslovakia. Organised by the Chamber of Commerce of Czechoslovakia, Rjna 13, Prague. Information obtainable from the Czechoslovak Commercial Attaché, 6 Upper Belgrave-street, London, S.W.1. (Tel. SLOane 0691); and the British Council for the Promotion of International Trade, 15 Hanover-square, London, W.1. Tel. MAYfair 0073.

Operational Research, International Conference on.—Mon., Sept. 2, to Fri., Sept. 6, at The University, Oxford. Object: to unify and extend the science of operational research. Organised jointly by the Operations Research Society of America, the Institute of Management Sciences, U.S.A., and the Operational Research Society of the United Kingdom. Apply to Dr. Thornton Page, Operations Research Office, 7100 Connecticut-avenue, Chevy Chase, Maryland, U.S.A., or to Mr. B. H. P. Rivett, hon. secretary, Operational Research Society of the United Kingdom, 2 Grosvenor-place, London, S.W.1.

Farnborough Flying Display and Exhibition.—Mon., Sept. 2, to Sun., Sept. 8, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 6, 7 and 8, only. Organised by the Society of British Aircraft Constructors Ltd., 29 King-street, London, S.W.1. Tel. TRAfalgar 3231.

Utrecht International Trade Fairs.—*Autumn Fair:* Tues., Sept. 3, to Thurs., Sept. 12, at the Croeselaan Site, Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

***Developments in Textile Research, Conference on.**—Wed., Sept. 4, to Fri., Sept. 6, at Boston, Mass., U.S.A. Apply to the Textile Institute, 10 Blackfriars-street, Manchester.

British Association Meeting.—Wed., Sept. 4, to Wed., Sept. 11, in Dublin. Apply to the secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See also ENGINEERING, June 28, page 805.

British Trade Fair and Exhibition.—Fri., Sept. 6, to Sun., Sept. 22, in Helsinki, Finland. Sponsored by the Federation of British Industries, the London Chamber of Commerce and the Finnish-British Trade Association. Supported by the Governments of Finland and the United Kingdom. Organised by British Overseas Fairs Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711.

***American Chemical Society, 132nd Meeting.**—Sun, Sept. 8, to Fri., Sept. 13, in New York. Organised by the Society, 1155 Sixteenth-street, Washington 6, D.C., U.S.A.

***Aeronautical Conference, Sixth Anglo-American.**—Mon., Sept. 9, to Thurs., Sept. 12, at Folkestone. Organised by the Royal Aeronautical Society, 4 Hamilton-place, London, W.1. Tel. GROsvenor 3515.

***Traction Meeting and Production Forum.**—Mon., Sept. 9, to Thurs., Sept. 12, at Milwaukee, Wis., U.S.A. Organised by the Society of Automotive Engineers, 485 Lexington-avenue, New York 17.

***American Mining Congress, Annual Convention.**—Mon., Sept. 9, to Thurs., Sept. 12, at Salt Lake City, Utah. Organised by the American Mining Congress, Ring Building, Washington 6, D.C., U.S.A.

***Nuclear Structure, International Conference on.**—Mon., Sept. 9, to Fri., Sept. 13, at Rehovoth. Sponsored by the International Union of Pure and Applied Physics. Apply to Dr. Amos de Shalit, Weizmann Institute of Science, Rehovoth, Israel.

***Macromolecular Chemistry, International Symposium on.**—Mon., Sept. 9, to Sun., Sept. 15, at Prague. Offices of the congress: 5 Technicka, Prague 6, Czechoslovakia.

Radio Isotopes in Scientific Research, International Conference.—Mon., Sept. 9, to Fri., Sept. 20, in Paris. Organised by the United Nations Educational, Scientific and Cultural Organisation. Apply to the United Kingdom National Commission for Unesco, Ministry of Education, Curzon-street, London, W.1. Tel. MAYfair 9400.

Food, Cookery and Catering Trades Exhibition.—Tues., Sept. 10, to Sat., Sept. 21, at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

***Co-ordination Chemistry, International Conference on.**—Sun., Sept. 15, to Fri., Sept 20, at Rome. Organised by the Italian Chemical Society, Via Quattro Novembre 154, Rome.

***Ship Hydrodynamics, International Conference on.**—Sun., Sept. 15, to Mon., Sept. 23, at Madrid. Apply to: Dr. M. L. Acevedo, Director, Canal de Experiencias Hidroinamicas, Ministerio de Marina, El Pardo, Madrid, Spain.

***Aviation Medicine, Second European Congress on.**—Mon., Sept. 16, to Wed., Sept. 18, at Stockholm. Apply to Dr. Olle Höök, secretary-general to the Congress, Flygvapnet, Stockholm 80, Sweden.

***Engineering Education and Training, Third International Conference on.**—Mon., Sept. 16, to Fri., Sept. 20, at Paris. Organised by the Engineers' Council for Professional Development, College of Engineering, New York University, New York 53.

Business Efficiency Exhibition.—Mon., Sept. 16, to Sat., Sept. 21, in Cape Town. Organised by the Cape Town Junior Chamber of Commerce, P.O. Box 204, Cape Town, South Africa.

***Interaction in Ionic Solutions, General Discussion on.**—Tues., Sept. 17, to Thurs., Sept. 19, at the University Laboratory of Physiology, South Parks-road, Oxford. Organised by the Faraday Society, 6 Gray's Inn-square, London, W.C.1. Tel. CHAncery 8101.

Association of Public Lighting Engineers, Annual Conference.—Tues., Sept. 17, to Fri., Sept. 20, in the Town Hall, Torquay. Exhibition of street lighting apparatus and an open-air display of lamp columns and tower wagons in the Upton Valley Gardens. Organised by the Association of Public Lighting Engineers, 17 Victoria-street, London, S.W.1. Tel. ABBey 4281.

Watch and Jewellery Trade Fair, Third International.—Thurs., Sept. 19, to Wed., Sept. 25, at the Royal Albert Hall, London, S.W.7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell-street, London, W.C.2. Tel. TEMple Bar 3422.

Stationery and Office Equipment Show.—Sat., Sept. 28, to Wed., Oct. 2, at the Conrad Hilton Hotel, Chicago. Organised by the National Stationery and Office Equipment Association, 750 Investment Building, Washington, D.C., U.S.A.

Perth Royal Agricultural Show.—Sat., Sept. 28, to Thurs., Oct. 3, at Perth. Organised by the Royal Agricultural Society, 9 Howard-street, Perth, Western Australia.

Canadian National Material Handling Show and Conference.—Mon., Sept. 30, to Fri., Oct. 4, at Montreal. Communications to Mr. E. Dupre, Northern Electric Co. Ltd., 150 Metropolitan Boulevard, Lachine, Quebec, Canada.

National Cattle and Agricultural Machinery Fair.—Early in October, at Quinta Normal, Santiago. Organised by the Sociedad Nacional de Agricultura, Tenderini 187, Santiago, Chile.

Gas Council's Fifth Sales and Service Conference.—Tues., Oct. 1, to Thurs., Oct. 3, at the Hotel Majestic, Harrogate, Yorkshire. General Theme: The Need for Training and Organisation in Salesmanship. Organised by the Gas Council, 1 Grosvenor-place, London, S.W.1. Tel. SLOane 4554.

Lubrication and Wear, Conference.—Tues., Oct. 1, to Thurs., Oct. 3, technical sessions in London. In addition, Mon., Sept. 30 and Fri., Oct. 4, will be devoted to whole-day and half-day excursions. Some of the papers will be re-discussed at subsequent meetings in Toronto and New York. Organised, with the collaboration of the American Society of Mechanical Engineers, by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. Tel. WHItehall 7476.

Films in the Service of Industry, Festival.—Tues., Oct. 8, to Sat., Oct. 12, at Harrogate, Yorkshire. Apply to the organising secretary, 3 Portman Chambers, 7 to 9 Baker-street, London, W.1. Tel. WELbeck 1104.

High Vacuum Technology, Fourth Annual Symposium.—Wed., Oct. 9, to Fri., Oct. 11, at the Hotel Somerset, Boston, Mass. U.S.A. Organised by the Committee on Vacuum Techniques, Box 1282, Boston 9, Mass., U.S.A.

Engineering Industries Association; 10th London Regional Display.—Wed., Oct. 9, to Fri., Oct. 11, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Society, 9 Seymour-street, London, W.1. Tel. WELbeck 2241.

Uses of Timber, Symposium on.—Fri., Oct. 11, to Tues., Oct. 15, at Lodge Hill Residential College, Pulborough, Sussex. Organised by the Timber Development Association, 21 College-hill, London, E.C.4. (Tel, CITy 4771.) Apply to the regional officer, 8 St. George's-place, Brighton 1.

Automatic Merchandising Convention and Exhibition.—Sun., Oct. 13, to Wed., Oct. 16, at the Convention Hall, Philadelphia. Organised by the National Automatic Merchandising Association, 7 South Dearborn-street, Chicago 3, Illinois, U.S.A.

Institute of Radio Engineers, Convention and Exposition.—Wed., Oct. 16, to Fri., Oct. 18, at the Canadian National Exhibition Park, Toronto. Organised by the Institute of Radio Engineers, Canadian Section, 745 Mount Pleasant-road, Toronto 7, Ontario, Canada.

Motor Show (42nd International Motor Exhibition).—Wed., Oct. 16, to Sat., Oct. 26, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

Factory Hygiene Medical Congress and Exhibition.—Thurs., Oct. 17, to Sat., Oct. 19, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA) Ehrenhof 4, Düsseldorf, Germany.

Electric and Atomic Show, International.—Fri., Oct. 18, to Sun., Oct. 27, at the Forum, Copenhagen. Organised by the Danish Electrical Development Association, Copenhagen, Denmark.

Canada's Power Show.—Mon., Oct. 21, to Thurs., Oct. 24, in the New Queen Elizabeth Building, Exhibition Park, Toronto. Organised by the Institute of Power Engineers, 199 Bay-street, Toronto, Ontario, Canada.

Coal Preparation, Second Symposium on.—Mon., Oct. 21, to Fri., Oct. 25, at The University, Leeds. Organised by the Coal Preparation Plant Association (P.O. Box 121), 301 Gossop-road, Sheffield 10. Tel. Sheffield 63031.

Fisheries Exhibition, International.—Mon., Oct. 21, to Sat., Oct. 26, at Lowestoft. Exhibition offices: Ludgate House, 110 Fleet-street, London, E.C.4. Tel. FLEet Street 6961.

Algiers International Trade Fair, 17th.—Fri., Oct. 25, to Mon., Nov. 11, in Algiers. Fair Offices: 3 Rue Jean-Rameau, Algiers, Algeria.

National Protective Packaging and Materials Handling Exposition.—Mon., Oct. 28, to Thurs., Oct. 31, in Atlantic City. Communications to Hanson and Shea Incorporated, 1 Gateway Centre, Pittsburgh, Pennsylvania, U.S.A.

Atomic Show.—Mon., Oct. 28, to Thurs., Oct. 31, at the Coliseum, New York. Organised by the Atomic Industrial Forum, 3 East 54th-street, New York 22, U.S.A.

World Metallurgical Congress, Second; and 39th National Metal Congress and Exposition.—Sat., Nov. 2, to Fri., Nov. 8, in Chicago. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

Measuring Instruments and Automation, International Congress and Exhibition (INTERKAMA).—Sat., Nov. 2, to Sun., Nov. 10, at the Ehrenhof Exhibition Grounds, Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany. (Additional information.)

Canadian National Packaging Exposition, Sixth.—Tues., Nov. 5, to Thurs., Nov. 7, in the Automotive Building, Canadian National Exhibition Park, Toronto. Organised by the Packaging Association of Canada, 1 St. Clair-avenue West, Toronto 7, Ontario, Canada.

Industrial Efficiency and Productivity Exhibition.—Tues., Nov. 5, to Sat., Nov. 16, at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

BEAMA Publicity Conference.—Thurs. and Fri., Nov. 7 and 8, at the Connaught Rooms, Great Queen-street, London, W.C.2. Attendance restricted to staffs of member-firms of BEAMA. Apply to the British Electrical and Allied Manufacturers' Association, 36 and 38 Kingsway, London, W.C.2. Tel. HOLborn 0502.

Scottish Motor Exhibition.—Fri., Nov. 8, to Sat., Nov. 16, at Kelvin Hall, Glasgow. Organised by the Scottish Motor Trade Association Ltd., 3 Palmerston-place, Edinburgh 12. Tel. Edinburgh Central 3643.

"macroPlastic" International Plastics Fair.—Wed., Nov. 13, to Wed., Nov. 20, in the RAI Buildings, Amsterdam, Holland. Organised under the auspices of the Dutch Government's Industrial Board and the Plastics Research Station of the Technical University. Further information obtainable from N.V. 't Raedthuys, Tesselschadestraat 5, Amsterdam, Holland.

Building Exhibition, 27th.—Wed., Nov. 13, to Wed., Nov. 27, at Olympia, London, W.14. Organised by the Building Trades Exhibition, Ltd., 32 Millbank, London, S.W.1. Tel. TATe Gallery 8134.

Royal Agricultural Winter Fair.—Fri., Nov. 15, to Sat., Nov. 23, at the Coliseum, Toronto. Offices: Royal Agricultural Winter Fair, Coliseum, Exhibition Park, Toronto, Canada.

Bogota International Fair, Fourth.—Fri., Nov. 22, to Sun., Dec. 8, at Bogota. Organised by the Corporacion de Ferias y Exposiciones, Edificio Avenida, Carrera 5a, No. 15-11, Bogota, Colombia.

Smithfield Show and Agricultural Machinery Exhibition.—Mon., Dec. 2, to Fri., Dec. 6, at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, W.1. Tel. GROsvenor 4040.

***Indian Science Congress Association, 45th Meeting.**—Thurs., Jan. 2, to Wed., Jan 8, 1958, in Calcutta. Organised by the Association, 1 Park-street, Calcutta 16, India.

***Synoptic Meteorology, World Meteorological Organization Commission for.**—Tues., Jan. 21, to Fri., Feb. 14, 1958, at New Delhi, India. Second session, organised by the W.M.O. Secretariat, Avenue de la Paix, Campaigne Rigot, Geneva, Switzerland.

***Canadian Institute of Surveying and Photogrammetry, Annual Meeting.**—Wed., Feb. 5, to Fri., Feb. 7, 1958, at Ottawa. Organised by the Institute, P.O. Box 57, Westboro, Ontario, Canada.

***National Association of Corrosion Engineers, Annual Conference.** Mon., Mar. 17, to Fri., Mar. 21, 1958, at San Francisco. Organised by the Association, Southern Standard Buildings, Houston 2, Texas, U.S.A.

***American Chemical Society, 133rd Meeting.**—Sun., April 13, to Fri., April 18, 1958, at San Francisco. Organised by the Society, 1155 Sixteenth-street, Washington 6, D.C., U.S.A.

***Electrochemical Society, General Meeting.**—Sun., April 27, to Thurs., May 1, 1958, at New York. Organised by the Society, 216 West 102nd-street, New York 25.

***Engineering Societies in Western Europe and the United States, Conference.**—Mon., April 28, to Sat., May 3, 1958, in New York. Apply to Colonel C. E. Davies, secretary, American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

***Institute of Metals, Jubilee Spring Meeting.**—Mon. April 28, to Fri., May 2, 1958, in London; and Mon. and Tues., May 5 and 6, 1958, at provincial centres. Organised by the Institute, 17 Belgrave-square, Westminster, London, S.W.1. Tel. BELgravia 3291.

Gauge and Tool Exhibition.—Mon., May 12, to Wed., May 28, 1958, at Olympia, London, W.14. Organised by the Gauge and Tool Makers' Association, Standbrook House, 2–5 Old Bond-street, London, W.1. Tel. HYDe Park 3451.

***International Water Supply Association, Fourth Congress.**—Sat., May 24, to Sat., May 31, 1958, at Brussels. Apply to Mr. L. Millis, O.B.E., International Water Supply Association, 34 Park-street, London, W.1. Tel. GROsvenor 1092.

In Parliament

TALL BUILDINGS IN THE BIG CITIES

Problems involved in the construction of tall buildings were raised in the House of Commons last week, when Mr. Raymond Gower (Conservative), asked Mr. Henry Brooke, the Minister of Housing and Local Government, to outline the policy of his Department respecting the institution of limited experiments with skyscrapers in the Greater London area and in the larger provincial towns.

A number of tall buildings, Mr. Brooke replied, had already received planning approval in London and in some of the major provincial cities. Other buildings of that kind were under consideration. The factors that had to be taken into account were the relationship of the building to neighbouring buildings or open spaces, the effect on the skyline, the ratio of floor-space to the site, the impact on traffic and the provision to be made for off-street parking. If all these aspects could be adequately resolved, he saw no objection to a tall building in the right place. If, however, Mr. Gower meant by " skyscrapers " buildings which were very much taller than any that had so far been approved, the matter would have to be approached with caution. The factors to which reference had already been made would apply, and the difficulty of securing a satisfactory result would increase with the height of the building. At the same time, Mr. Brooke said, he would not rule out even a very tall building in principle.

POLLUTION BY POWER STATIONS

Answering an inquiry by Mr. P. J. Noel-Baker (Labour) regarding clean air requirements at power stations, Mr. Henry Brooke said that the Senior Alkali Inspector had no power at present, under the regulations of the Ministry of Housing and Local Government, to prevent air pollution by electricity power stations. The question whether further categories of works, including power stations, should be brought within the scope of the Alkali Act had been the subject of a recent public inquiry and a decision would be reached in due course. Mr. Brooke said that when Lord Mills, the Minister of Power, gave consent to the construction of a new power station, or for the extension of an existing station, he normally required the use of the most efficient methods reasonably practicable for the elimination of smoke and grit.

LONDON AIR TERMINALS

A short discussion on air terminals in London was initiated by Mr. Frank Beswick (Labour/Co-operative), who asked what arrangements were being made for the provision of a building capable of accommodating passengers of the British European Airways, the British Overseas Airways Corporation, the foreign airlines for whom they act as agents, and the other independent operators in five years' time. He pointed out that the new buildings now under construction at Cromwell-road comprised the third air terminal which the B.E.A. had built since the war and that even it would be inadequate for future passenger requirements. The necessity of co-ordinating the needs of the various air-transport companies was bound up in this problem, as also were the proposals for the construction of a railway link with London Airport.

Mr. Airey Neave, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that Air Terminals Limited, the private company which was constructing the new terminal at the Cromwell Curve, had stated that the buildings now under construction would cost £250,000. These buildings would be adequate for meeting the requirements of short-haul operators over the coming ten years. The site was capable of extensive further development. He understood, however, that the B.O.A.C. did not propose to use the Cromwell Curve Terminal, but were intending, in the first place, to develop their present terminal in Buckingham Palace-road. He agreed that the Cromwell Curve Terminal, the B.O.A.C. building in Buckingham Palace-road and the railway link with London Airport were all part of the same problem. The matter was still under consideration by the airline Corporations and the British Transport Commission. He told Mr. J. A. Langford-Holt (Conservative) that nothing had so far been arranged regarding a stopping place for B.O.A.C. passengers who arrived at London Airport and wished to alight in West London areas.

Mr. John Rankin (Labour/Co-operative) asked if it were correct that a station was being built under the Cromwell Curve Terminal, or would users of the air services have to proceed from the terminal to Gloucester Road Station ? Mr. Arthur Woodburn (Labour) suggested that Gloucester Road Station should be extended in order to give an entrance to the new terminal. In reply, Mr. Neave said that no station was being built under the terminal. The present construction on the terminal was taking place on the approach to the station.

NEW IDEAS ON ROAD SIGNS

Another subject discussed was the introduction of new types of road signs. Mr. J. A. Langford-Holt (Conservative) wanted the Minister of Transport and Civil Aviation to request the Road Research Laboratory to investigate the legibility of traffic signs with the standard black lettering and numbering on a light background compared with signs having white lettering and numbering on a dark background, such as were being used experimentally on road A40, between Sandhills and the Islip Turn. Mr. Ernest Davies (Labour) was concerned about the Minister's request to the Oxford County Council to withdraw the directional signs erected on the Oxford-to-London road. He felt that they approached closely to the signs recommended by the International Convention on Road Signs.

Mr. Harold Watkins, in his reply, stressed the fact that these signs were diversionary signs and were originally erected on a temporary basis only, during road-construction work. They did not conform to the signs authorised under the Road Traffic Acts and, therefore, the Ministry's divisional road engineer was in duty bound to say that they must come down. Mr. Watkinson said he had now decided to approve the new signs on an experimental basis, as part of the investigation being carried out in conjunction with the Road Research Laboratory into the merits of different types of directional signs. He felt that their retention could well form part of the general experiment being made to bring British road signs rather nearer to those used on the Continent. The cost of such action would be over £4 million.

Colonial Hydro-Electric Power

Answering a question by Mr. James Johnson (Labour) regarding the steps being taken by the Demerara Bauxite Company to develop the water power resources of the Essequibo River, British Guiana, Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, said that the report on the hydro-electric investigations carried out by the company stated that water-power development at Great Falls, Mallali and Tiger Hill was technically feasible. The cost, however, would be high and the company had reluctantly decided, on economic grounds, that it could not proceed further with its application for a licence. Investigations into the possibilities of the Kaieteur-Amatuk area were being continued.

Sheet and Strip Steel Supplies

Mr. Reginald Maudling, the Paymaster-General, told Mr. R. Gresham Cooke (Conservative) that, according to information which he had received from the Iron and Steel Board, plans were in hand for the expansion of existing wide strip mills so as to provide, by 1960, for an annual sheet output of over 750,000 tons more than in 1956. Plans for the provision of further sheet and strip steel capacity after 1960 were under discussion between the Board and the steel industry. The Board's report was expected shortly.

Saving Coal

Mr. A. M. F. Palmer (Labour/Co-operative) wanted the Paymaster-General to supply particulars of the approximate quantity and the estimated value of the coal saved by the nationalised gas and electricity industries, due to the increased efficiency of fuel utilisation, since vesting day. Mr. Maudling replied that in the gas industry, nearly 10 million tons, worth around £40 million, had been saved. In the case of the electrical industry, the figures were 35 million tons and the value about £120 million. It was certainly an excellent performance, but there had been plenty of excellent performances in private industry also.

Farm Buildings Research

Mr. Derick Heathcoat Amory, the Minister of Agriculture, Fisheries and Food, speaking as a representative in the Commons of Lord Home, the Lord President of the Council, informed Mr. Frederick Willey (Labour) that the Farm Building Research Committee set up by the Agricultural Research Council had decided that further information was needed before a conclusion could be reached regarding the desirability of establishing a farm buildings research station.

Derwent Valley Reservoir Project

Questions were put to the Minister of Housing and Local Government by Mr. C. F. Grey (Labour) and Mr. J. W. Ainsley (Labour) asking when a decision would be reached regarding the proposals to construct a reservoir in the Derwent Valley. Mr. Henry Brooke said that the report of the public inquiry held locally by the Ministry's engineering and planning inspectors on the proposals of the Durham County Water Board was now under consideration. It was hoped to announce a decision shortly.

Technicians in Government Service

The number of scientists and technicians employed in the defence Ministries has been reduced by 800 since the beginning of the present year and this process will continue, according to an answer given by Mr. Duncan Sandys, the Minister of Defence, to Mr. George Brown (Labour). The Minister assured Mr. Brown that there has been no change in the Government's policy in this respect.

Tolls on New Bridges

The policy of his Ministry, Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, told Lieut.-Colonel W. H. Bromley-Davenport (Conservative), was to impose tolls on certain very costly new bridge and tunnel projects, where the present inconvenience to road users would be heavily outweighed by the value of the improved facilities. The priority given to these projects was governed by the same factors as applied to major road schemes, except that, without tolls, the projects could not be included in the programme at all. In the circumstances, he could not give a high priority to expenditure for the redemption of privately-owned toll rights.

Trading with Brazil

Delays in the payment for goods exported in Brazil before 1953 had certainly discouraged United Kingdom exporters from seeking new business, Sir David Eccles, the President of the Board of Trade, told Mr. Will Owen (Labour/Co-operative). The 1953 agreement for paying the arrears of commercial debts, amounting to £64 million, at the rate of £6 million a year, had been working well. Trade had revived and exports to Brazil, which, in 1955, were less than £7 million, were now running at about £18 million a year.

THE HUMAN ELEMENT

Beyond the Bowler Hat

It is today almost a truism that the pensioned regular officer needs assistance in choosing a civilian career. Emphasis is laid, and rightly,on the limited opportunity which exists for the average officer (meaning by that the ones who cannot get the job they want on an " old boy " basis) to train himself quickly to acquire a position which is at all comparable to his recent situation in the Armed Services. Several organisations and consultancy groups are available to help in this process of readjustment. Before it becomes the accepted idea that all that is required is for such men to get a grasp of the general industrial situation, equip themselves with a body of knowledge to be grafted on to their experience and then sell themselves, certain basic issues must be faced.

The human problem of adjustment is a big one and cannot be overcome quickly by " swotting " or salesmanship. Its existence must be realised by all sympathetic would-be employers. The man who comes out of the Services is leaving behind with his uniforms a machine, a code of loyalty and a way of life. He brings with him a pension. Except in a battle sense he usually knows as little about the battle of survival as the average civil servant or university teacher. He may have taken risks because of ambition but he has not known certain types of insecurity such as occur in business and professional life. The jump from an attitude of service to commercial shrewdness is not for all of them to take. These facts must be faced in the near future when so many more men of ability are coming out of the services in search of civilian employment. There is plenty of work they can do in civilian life but they will have to be fitted into the right place with care.

Out into Space

Not the least of the unknowns which have to be solved—at least in part—before satellite flight in sub-gravity regions becomes a commonplace for human beings is the reaction to environment. All that is known at present is that concentration upon instruments over a period of time with no other interest to absorb the concentration is liable to cause big lapeses in efficiency—lapses which will vary considerably between different people. To put it in very lay terms, the human may take unkindly to being hurtled through space at low air pressures and low gravity with only instruments to console him and absorb his attention.

These problems were discussed recently in a paper by Lt.-Colonel J. P. Henry, of the U.S.A. Air Research and Development Command, at the High Altitude and Satellite Rocket Symposium organised jointly by the College of Aeronautics, the Royal Aeronautical Society and the British Interplanetary Society. The line of progress according to Colonel Henry is to design " meaningful stimuli and significant tasks."

Training Engineering Administrators

A scheme to attract the interest of the young in project management is shortly to be tried out by Holland & Hannen and Cubitts Limited. The company is inviting up to six boys between the ages of 16 and 18 from each of the 120 secondary grammar and public schools in the London postal area to attend a two-day course. This will take place in London in September.

The scheme is of considerable interest. The idea of training youngsters early and systematically for administrative work of a high order in parallel with engineers working in the field is an excellent one. It brings to the civil engineer on site the same kind of assistance and problems of compromise which exist today for the engineer in the factory. Such a marriage is all to the good. The complexity of civil engineering work today puts a high premium on administrative ability. It is important however (and the Cubitts scheme makes provision for it) that promotion and transfer should be possible between one and the other. It would defeat its own ends to have engineers eternally co-ordinated by administrators as a race apart—or vice versa.

Strikes—Against Differentials

A strike of 100,000 provincial busmen began last week-end, over a pay dispute. The employers have turned down the claim by the six unions concerned for £1 a week increase in wages and have offered 3*s*. Their suggestion that the dispute should be referred to the Industrial Disputes Tribunal for arbitration was refused. The unions considered asking Mr. Ian McLeod, the Minister of Labour, to set up a court of inquiry instead of referring the matter to arbitration. But this, too, was rejected at a meeting attended by Mr. Frank Cousins, the ex-lorry driver general secretary of the Transport and General Workers' Union. Despite the fact that the strike will be expensive and unpopular, the union leaders are determined not to repeat the experience of seven months ago, when arbitrators awarded a 5*s*. a week increase instead of the £1 claimed at the time.

Meanwhile, Mr. McLeod has called for a meeting of the Industrial Disputes Tribunal to consider the unions' claim and hearings began this week, without the unions' co-operation. This means that an award will be made, presumably on normal cost-of-living index considerations. The unions' objective is the closure of the gap between the earnings of provincial busmen and those of London Transport bus workers. The situation is complicated further by differences in the views of municipal, and private employers. The former have offered a 7*s*. 6*d*. increase, more than twice the " final offer " of private employers.

The findings of an arbitration tribunal set up under the Industrial Disputes Order are enforceable in the Courts. The interest of this case lies in whether or not the unions can, by boycott of the tribunal and by strike action, ride roughshod over the law of the land. Should they do so successfully, the whole arbitration procedure lies exposed to unilateral action.

In Defence of Tradition

The refusal last week of 1,200 market men at Covent Garden to accept a wage award by an independent arbitrator is further evidence of the growing weakness of the Ministry of Labour's arbitration procedure. Like the provincial busmen, the market workers are fighting for something wider than a wage increase. Basically, the dispute is over the proposals of the Covent Garden Tenants' Association for a re-organisation of the market's labour force. A plan to re-organise the pitchers, who unload incoming vehicles, the staff men, who handle the produce within the wholesalers' premises and the porters, who load outgoing vehicles, arises from recommendations made in the report of the Runciman Committee on Horticultural Marketing.

Published at the beginning of the year, the Runciman report criticised existing labour arrangements and suggested that " if improved handling methods, including the use of mechanical devices, were to be introduced more extensively, greater co-ordination of the three groups of workers was desirable." The arbitrator accepted the principle of unification of labour in making his award. While accepting his award, the unions refused to accept the consequent re-organisation of their members and, according to the employers, refused " to co-operate in any way in its implementation."

The last word has not been spoken. The Minister of Labour considers that there is scope for " further explanation." The key to peaceful co-operation—the putting over of the case for new methods of handling and consequent re-grouping of labour—may well lie there.

Merging Clerical Grades

Proposals for a simplification of the grading system for clerks in local government offices have been made by the staff side of the national joint council for local government services. The aim is to provide better career prospects in the service, and to narrow the gap between salaries in local government employment and those in comparable posts in industry. A spokesman of the National and Local Government Officers' Association said that local authorities were losing experienced officers at a rate which threatened the efficiency of local government service.

The staff side's proposals would yield substantial improvements in pay and a simpler promotion scale. The lower general division would be abolished and the salary scale of the higher general division raised by £45 10*s*. at the lower end, to £230 a year, and by £107 10*s*. at the top to £620. The four clerical grades would be merged and a new salary scale established to £650 rising to £800. The seven administrative, professional and technical grades would be reduced to four and the salary range increased to £600 rising to £1,650.

The national joint council are not fully agreed on the details of the staff side's proposals, but the two sides were said to be " drawing closer together." Such changes would be welcomed by local authority engineers.

Mortgages on the Cheap

Giving the Chartered Surveyors' Gold Medal and Prize paper last week at Nottingham, Dr. W. K. Logan drew attention to one of the consequences of chronic inflation, namely, its effect on house values and borrowing terms. The rate of interest on mortgages, according to Dr. Logan, has been less than the rise in the value of property caused by the general rise in prices. It is significant that such a calculation has been made. It means that in real terms houses have been bought at what can be called " negative " interest rates.

The general principle from which all this stems is widely known. Inflation favours those who borrow and penalises those who lend. It assists those who can take advantage of the rise either because they are residuary legatees (like shareholders) or in a strong bargaining position (like organised labour). It works against those dependent on fixed incomes whose liabilities increase as the real value of money falls.

Socially, the consequences are somewhat ironical. So far as houses are concerned, buyers have been favoured, owners penalised. Owner-occupiers have had the best of both worlds. The owners, under the subsidised house building and renting policy carried out since the war, have provided accommodation on the cheap because their capital assets (namely the houses) have not been allowed to earn their market price in rent. The owners in this case have been the ratepayers and taxpayers who have stood the subsidy bill.

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